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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CIV.—No. 2704.] *LONDON: FRIDAY, OCTOBER 26, 1917.* [*Registered at the General Post Office as a Newspaper.*] PRICE 9d. BY INLAND POST...10d.

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See page 110, Oct. 19. 5784

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See Advertisement page 113. 3101

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See Illustrated Advt. in alternate issues. Od 3382

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See half-page Advertisement, last and next week.

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6064
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See Full Page Advt., page 63, Oct. 19.

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See half-page Advertisement page 79, Oct. 5.

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TENDERS.

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Tenders for the Supply of the following STORES, namely:—
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HELICAL SPRINGS;
SPARE PARTS OF CARRIAGES AND WAGONS;
WHEELS AND WAGONS;
TYRE RETAINING RINGS;
YORKSHIRE IRON SCREW COUPLINGS.

Specifications and Forms of Tender may be obtained at this Office on payment of the fee for the Specification, which payment will not be returned.
Tenders must be delivered in separate envelopes, sealed and addressed to the undersigned, marked "Tender for Steel Tyres for Carriages and Wagons," or as the case may be, not later than Eleven o'clock a.m., on Thursday, the 1st November, 1917.
The Directors do not bind themselves to accept the lowest or any Tender.
R. H. WALPOLE, Secretary.
Company's Offices,
48, Copthall Avenue, E.C.,
London, 24th October, 1917. J 213

CONTRACTS, &c.

GREAT SOUTHERN & WESTERN RAILWAY (IRELAND)

CONTRACTS, 1918.

The Directors of the Great Southern and Western Railway Company are prepared to receive

Tenders for the Supply of the undermentioned STORES for Twelve Months to 31st December, 1918, or part of that period:—

	No. of Form.		No. of Form.
Acid, Sulphuric	3b	Incandescent Fittings for Gas	36c
Baskets	10	India Rubber Goods	9a
Bolts, Nuts and Rivets	15	Implements, Sundry	21
Brooms and Brushes	13	Iron Tubes and Fittings	29
Brass Fittings for Carriages	18	Iron and Steel Wire	30a
Do. do. for Lamps	18a	Leather	12
Do. do. for Water	26a	Linen	8
Do. do. for Gas	36b	Linoleum	7b
Bunting	7b	Locks and Keys	19
Canvas and Sacks	6	Mats, Fibre	10
Carriage Laces	7a	Morocco	7b
Castings, Mall. Iron	11	Nails	31
Cement	34	Oak Keys	35a
Cloth, Carr. and Uniforms	7c	Oak Trenails	35b
Clothing, Oil	9b	Plumbago	41
Do. I.R. proofed	9b	Railway Fastenings (Iron)	16
Coach Screws and Washers	15	Railway Fastenings (Steel)	16a
Colours	2	Rain Water Pipes and Gutters	25
Corks	39	Ropes, Twine, and Flax	4
Cotton Waste	5a	Sewer Pipes, Plaster, etc.	33
Crucibles	41	Shovels, Spades, etc.	21a
Curled Hair	7b	Soft Goods	8
Drysalteries	3	Sponge Cloths	5
Emery and Glass Cloth, etc.	38	Signal Wire Pulleys	11
Files and Tool Steel	20	Screws and Split Pins	14
Fire Bricks and Clay	33	Tin Plates	23
Foundry Requisites	42	Varnishes	1
Galv. Sheets, Buckets, etc.	23	Waste	5a
Grates, Stoves and Fenders	34	Waterproof Clothing	9b
Grindstones	38	Wicks	5
Glass, Sheet and Plate	27a	Wire, Fence and Signal	30a
Glass and China Sundries	37b	Wirework	22c
Hardware (Sundry)	17		

Forms of Tender can be obtained on *PAYMENT* of 6d. each from the COMPANY'S STOREKEEPER, AT THE GENERAL STORES, INCHICORE, Dublin, to whom enquiries for information should be made direct. Patterns may be inspected at the same place on and after the 29th instant between the hours of Ten a.m. and Four p.m. (except on Saturdays).
The Tenders to be sent in endorsed "Tender for Stores," and addressed to the undersigned, so as to be with him before Ten o'clock, a.m., on Wednesday the 14th November, 1917.
The Directors will not consider any Tender except those furnished on the Company's Forms, and do not bind themselves to accept the lowest or any Tender.
By Order,
ROBERT CRAWFORD,
Secretary.
Kingsbridge Terminus, Dublin,
October, 1917. J 174

APPOINTMENTS OPEN.

HALIFAX EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL COLLEGE.
Principal, J. Crowther, B.Sc.

Applications are Invited for the post of ASSISTANT in the Mechanical and Electrical Engineering Department. Salary £175 per annum. Candidates must be ineligible for military service. Teaching experience including laboratory work, and practical experience in an engineering works essential.
Particulars and forms of application, to be returned as early as possible, may be obtained from the PRINCIPAL, or from the undersigned.
W. H. OSTLER,
Secretary. J 126

KENT EDUCATION COMMITTEE.

JUNIOR TECHNICAL SCHOOL, GRAVESEND.

Required, in January, 1918, ASSISTANT MASTER to teach Engineering Subjects and Mathematics. Preference will be given to candidates who have had teaching and workshop experience. Initial salary £200 per annum.
Forms of application and further particulars can be obtained from the Local Secretary, Technical Institute, Gravesend.
Applications to be sent to the Head Master, Mr. G. Victor Burgess, B.Sc., by November 25th.
FRAS. W. CROOK, J 186
October, 1917. Secretary.

KENT EDUCATION COMMITTEE.

DAY JUNIOR TECHNICAL AND COMMERCIAL SCHOOLS, MAIDSTONE.

Required as Soon as Possible for the above Schools, which are about to be opened, an ASSISTANT MASTER. Graduate in Engineering with workshop experience preferred. Initial salary £200 a year. Last date for receipt of applications November 17th, 1917.
Forms of application may be obtained from H. W. B. Abbott, Esq., Technical Institute, Maidstone.
FRAS. W. CROOK, J 187
October, 1917. Secretary.

Wanted, at Once, Teachers of Mathematics, Machine Drawing, Applied Mechanics, &c., for Junior Technical School.—Application forms may be obtained from J. BAGLEE, Principal, Technical College, Doncaster. J 182

Metallurgist.—An Important Engineering Firm, about to equip a modern Metallurgical and Pyrometry Department, will REQUIRE the services of a CHIEF who has had practical experience with steel, alloy steels, cast iron, bronzes, &c. Applicants should give full particulars of their training and works experience, also state age and salary required. — Address, J 100, Offices of Engineering.

Required, in Government Factory, METALLURGICAL CHEMIST, for analysis of ferrous and non-ferrous alloys. Previous experience preferable but not essential. Men already on Government work need not apply.—Apply, giving full details of experience and salary required, to the nearest EMPLOYMENT EXCHANGE, mentioning this paper and No. A 3385. J 160

Wanted, Competent Man as WORKS MANAGER, for first-class Engineering and Loom Works. Must have practical knowledge, and be capable of taking full control of the whole inside arrangements. State age, salary and experience required.—Address, J 193, Offices of Engineering.

Machine Shop Manager Required by a large industrial firm in the Midlands; must have had experience of repetition and jobbing work and be able to handle labour successfully. Permanent position is offered to a first-class man. No one at present on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3394. J 167

Assistant to General Manager WANTED, by controlled Midland firm of Machine Tool Makers, with about 100 employees. Age about 30. Good prospects to man with energy and initiative, as selected applicant, with co-operation of works superintendent, will be responsible for management during absence of principal. State age, salary, full experience and when disengaged. No one already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 208.

Required, in Government Factory, for work in connection with Aeroplanes and Aeroplane Engines, several YOUNG MEN with scientific engineering training. Previous experience of aeroplanes not essential. Men already on Government work need not apply.—Send full details of experience and salary required to your nearest EMPLOYMENT EXCHANGE and quote reference number A 3359. J 163

Works Accountant Wanted, to take charge of general office of Controlled Engineering Firm employing 600 hands. Essential qualifications—
1. Knowledge, with Practice, in Up-to-date Cost, Time and Book-keeping Systems.
2. Energy and Initiative.
State experience, naming employers, age, military liability and salary required. Progressive position for suitable man. No one already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 181.

Chief Clerk Required by Controlled Firm in Midlands, to take charge of Office with four Juniors. Thorough knowledge of Book-keeping necessary, and experience in costing an advantage. State age, salary, experience, and when disengaged. No one already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 209.

Male Clerk Wanted, to deal with Inwards Traffic of large Controlled Factory, with experience in the preparation of Mineral Traffic Returns preferred. Good salary will be paid to suitable man.—Apply, with full particulars, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3363. No person already on Government work will be engaged. J 171

Clerk Required for Assisting in Purchase Department of large Engineering Works in Essex. State experience, age and wages required. No one already on Government work will be engaged.—Apply to nearest EMPLOYMENT EXCHANGE, mentioning this Journal and reference J 191.

Wanted, Prime Cost Clerk for Engineering Works; must have experience and technical knowledge of machinery parts; for Controlled Establishment in East Anglia. No one employed on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 179.

Wanted, Commercial Engineer, sound technical training, knowledge of induced draught fans preferred. Age about 30. No one already on Government work or residing more than ten miles away will be engaged.—Write, stating age, experience, and salary required, to J 168, Offices of Engineering.

Aeronautical Engineers, London, N.W., have VACANCIES for DRAUGHTSMEN preferably, but not necessarily with previous experience of aircraft work. Apply by letter, stating age, salary, particulars of experience and when disengaged. No one need apply who is engaged on Government work or who resides more than ten miles away.—BOX B 514, Sells, Ltd., Fleet Street, E.C. 4. H 965

Required, in London Drawing Office of a Government Department, CIVIL ENGINEERING ASSISTANTS; must be ineligible for general military service; good draughtsmen and well versed in engineering calculations.—State experience, salary required, and forward copies of references to BOX No. 866, care of Streets, 9, Serle Street, W.C. J 131

Designing Draughtsman (experienced) and skilled LATHE HAND WANTED for experimental aero engine work, employment continuing after war if satisfactory. Salary and increasing bonus. No person resident more than ten miles away or already engaged on Government work will be engaged.—ENGINE PATENTS, Ltd., 21, Suffolk St., Pall Mall. J 189

Mechanical Engineering ASSISTANT with all-round scientific education and training, for chemical works in Midlands. Must be accurate, reliable, versatile, and energetic. No person already on Government work will be engaged.—Apply, stating age, education and training, experience, posts held, salary expected, references, and when free to take up duties if engaged, to your nearest EMPLOYMENT EXCHANGE, mentioning this Paper and J 190.

Chief Draughtsman and Designer, 14 years' experience in construction and design of commercial motor vehicles, SEEKS POST. Thoroughly conversant with modern machine shop methods.—Address, J 159, Offices of Engineering.

First-class Draughtsman, with Steam Crane experience, WANTED at once. No one already employed on Government work will be engaged.—Apply, giving full particulars, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 194.

Leading Firm of Heating Engineers in Provinces REQUIRE DRAUGHTSMAN for Government work.—Apply, stating age, qualifications and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 43. No one already employed on Government work will be engaged.

London Engineering Firm REQUIRES DRAUGHTSMAN, with good general engineering experience. Preference given to those having workshop experience. No one living more than ten miles away or already engaged on Government work will be engaged.—State age, experience and salary required to J 172, Offices of Engineering.

Draughtsmen Required for special work under the Admiralty.
(a) Four Mechanical Draughtsmen, must be first-class men with good general engineering experience and technical training. Those used to light interchangeable work preferred but not essential.
(b) One Ship Draughtsman used to Admiralty practice, and with experience in ship's deck fittings preferred.
Address, J 132, Offices of Engineering.

Draughtsman Wanted, used to steel and reinforced concrete work. No one residing more than 10 miles away or already on Government work will be engaged.—Apply, stating age and salary required, also earliest date could commence, to SOMERVILLE Ltd., 120, Victoria Street, S.W., 1. J 156

Wanted, for the Electrical Engineer's Department of a large steel and iron company in the North Midlands, several good DRAUGHTSMEN, who have had experience in the design of H.H.T. and H.T. sub-stations, and the lay-out and installation of motors, cables, switchgear and special appliances in connection with the driving of heavy steel works or other similar plant engaged on varied classes of war work. Applicants are requested to give their age and submit references and details of their training and experience; also to state the wages required and the earliest date upon which they could take up their duties if selected for the post. No person already engaged on Government work will be employed.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and J 164.

Wanted, Draughtsman for the mechanical design of large electrical direct current machines. Nobody engaged on Government work will be accepted.—Write or apply to the nearest Board of Trade EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 3631. G 457

Draughtsman Wanted for General Work. Controlled Establishment near London. State age, experience, salary required and when at liberty. No person employed on Government work will be engaged.—Apply, nearest EMPLOYMENT EXCHANGE, mentioning Engineering and No. 4039/701/319. J 10

Wanted, One or Two First-class DRAUGHTSMEN, thoroughly experienced in high-class instruments design, for important Government work.—Address, giving full particulars of qualifications, stating wages required and when at liberty, J 6, Offices of Engineering.

Six Draughtsmen Wanted, accustomed to iron and steel works practice, for construction of New Steel Works, East Coast. No person already engaged on Government work will be engaged.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3810. J 224

Draughtsman Wanted with experience in Motor Vehicle design. Commercial vehicle experience desired but not essential. Good salary and prospects for man with initiative and the right experience.—Apply to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3569. No person already employed on Government work will be engaged. J 204

Draughtsman Wanted at Once. Experienced mechanical draughtsman for the engineering department of large factory in the Midlands. Only men with first-class experience will be considered. No one engaged on Government will be employed.—Apply, giving full particulars of experience, salary required, &c., to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3889. J 221

Draughtsmen (two), Mechanical, REQUIRED, by Midland manufacturing firm. Preference given to men with experience of modern steam and electrical plant and general mill work.—Apply, giving age, experience, salary required, and references, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A. 3887. No one on Government work will be engaged. J 220

Wanted, Draughtsman for Controlled Establishment. One with knowledge of Grinding and Seed Crushing Plant preferred, but not essential. No one already engaged on Government work need apply.—Apply, stating full particulars and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and H 874.

Jig and Tool Draughtsmen. —First-class men REQUIRED by large Controlled Factory in Midlands; must be conversant with up-to-date practice in motor car, aeroplane and engine manufacture; really good men only need apply. No person already on Government work will be engaged.—Apply, your nearest EMPLOYMENT EXCHANGE, stating age, experience and salary required and when able to commence, mentioning No. A 3346. J 131

First-class Mechanical DRAUGHTSMAN REQUIRED for Controlled Works in South Wales. Must be capable of designing machinery, &c., and have had good general experience, including lay out of new plant. No one already employed on Government work will be engaged.—Apply, stating qualifications and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting J 128, and Engineering.

One or Two Competent DRAUGHTSMEN required, with experience in design and detailing of rolling and drawing machinery, structural steel work and works plant generally, for important Government War work. Applications are invited only from accurate and reliable men. Salary according to experience. No person on Government work will be engaged. Apply, stating age and fullest detailed particulars of experience to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and No. A 3833. J 96

Wanted, Technical Design ASSISTANTS for electrical firm in the Midlands. Experience of transformer and alternating current design advantageous. Nobody engaged on Government work need apply.—Apply, stating age and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 3805. J 39

Engineer or Capable Foreman WANTED at once to take charge of maintenance of machinery on the night shift in large factory in the Midlands. Applicants must have first-class experience in the running of heavy plant, including hydraulic machinery. Experience in three phase electrical work will be an advantage though not essential. No one at present on Government work will be engaged.—Apply, with full experience, salary required and when free, to your nearest EMPLOYMENT EXCHANGE mentioning A 3882. J 165

Required, for Controlled Establishment in the Midlands, the services of a First-class FOREMAN TOOLMAKER, to take full charge of Tool Room and separate Tool Stores of a new Munition Factory.
Only men experienced in the making and hardening of accurate jigs, gauges, gear cutters, taps and hobs would suit.
A thoroughly practical man, with good technical training and capable of making the most of a thoroughly up-to-date tool room plant, is required.
No person already on Government work will be engaged.—Apply, in the first instance, to the nearest EMPLOYMENT EXCHANGE, mentioning No. A 3852. J 161

THE TIGRIS FLOTILLA OF GUNBOATS.

The Tigris flotilla of gunboats, referred to in Captain Nunn's report describing the share the Navy took in the capture of Baghdad, consisted of a number of very shallow-draught vessels, termed the "Fly" Class, so called because their names terminated with the word "fly"—such as Firefly, Butterfly, &c. These vessels were ordered from Messrs. Yarrow, in February, 1915, by Lord Fisher, then First Sea Lord; and, in order to avoid the "red tape" inevitable to Government departments, Lord Fisher, with the concurrence of the Admiralty technical authorities, gave the Yarrow firm a free hand as regards their design and construction. Twelve gunboats were ordered in the first instance, and, after the capture of the Firefly by the Turks, the Admiralty increased the number to 16. The object Lord Fisher had in view was that these vessels should police the Tigris, operating against the Arab tribes, who were constantly giving trouble by attacking passing steamers, by firing at them from the river banks. Although these vessels were not specially designed to meet artillery, Captain Nunn states they were of invaluable service in co-operating with the land forces when dealing with the Turkish Army.

The form of hull was carefully determined with the assistance of the authorities at the National Physical Laboratory, at Teddington, who have charge of the Experimental Tank, in order to secure the minimum resistance with the dimensions admissible. The Tigris, as is well known, is an exceptionally tortuous river, and, in places, exceedingly shallow, the sandbanks shifting from day to day. It was therefore desirable to adopt a type of vessel having the lightest possible draught, and as small as was consistent with other requirements, so that when a vessel ran aground the difficulty of hauling it off should be minimised. The length of 120 ft., and a beam of 20 ft., was determined upon, with a draught of 2 ft. 6 in. The draught, in fighting trim, was so small that when the river overflowed its banks it was possible to save a great deal of time by cutting off the bends; as a matter of fact, the Arab pilots often indicated the course over the shallows by walking in the water ahead of the vessel.

Having in view the urgent need for these vessels at the earliest possible date, the design, in a great measure, was determined by considerations of rapidity and simplicity of construction, and thus a single screw was adopted. The screw-in-tunnel, with Yarrow's patent hinged flap, was the mode of propulsion selected. This hinged flap, as is well-known, secures the best result under all conditions of load, and prevents the tunnel being suddenly emptied when meeting the wash from passing steamers. It also gives better control when going astern, in which respect shallow-draught vessels, propelled either by stern-wheels or screws, are deficient. The success of this system of propulsion is now well established, as, for example, in the case of the Shu-hun*, which vessel, since 1914, has regularly navigated the rapids of the Upper Yang-tsze-kiang, which were obstacles to steam vessels prior to the introduction of this system. The propelling machinery consisted of a set of triple-expansion engines, and one Yarrow boiler fired with oil fuel—of which there was ample available from the Anglo-Persian Oil Company's refinery, which obtains its supply through a pipe-line running into the interior of Persia. The boiler was fitted with fire-bars and arranged for burning coal, so as to provide for the contingency of the oil supply being cut off by the Turkish troops. At first it was proposed to proportion the boilers for burning wood, but it was found that, since the days of the Garden of Eden, trees, with the exception of a few palms, had disappeared from the Tigris Valley!

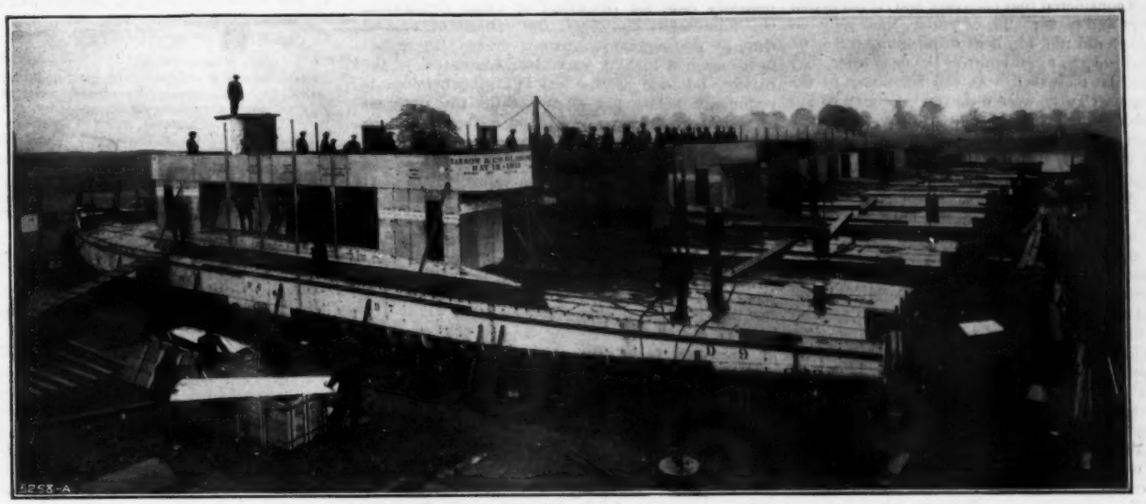


Fig. 1. Vessels being Dissembled at Messrs. Yarrow's Scotstoun Yard, Glasgow.

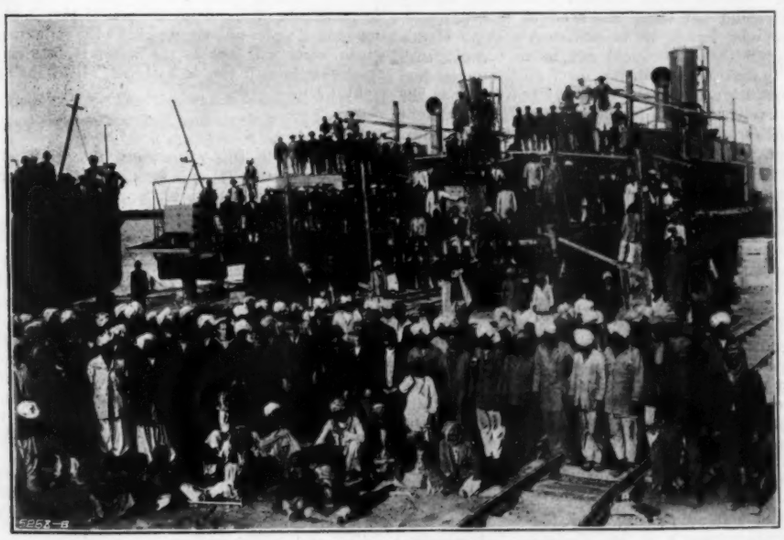


Fig. 2. The Workers in the Mesopotamia Yard.

All the hulls were temporarily erected in the Yarrow yard, for shipment in pieces, as is shown in Fig. 1, annexed. The machinery was fixed in in position, and the pipes connected up on one of the vessels, which thus served as templates for the others. No difficulty was experienced in re-erecting and completing the vessels on the Tigris. Instruction to proceed with these gunboats was given on February 9, 1915, and the last of the 12 vessels was finished, ready for shipment to the Persian Gulf, on August 11 following. Operations on the Tigris were commenced on August 24, 1915, when the keel of the first vessel, the Firefly, was laid at Abadan. Abadan is 32 miles below Basra, and was selected for the re-erection of the vessels so as to secure the co-operation of the staff and appliances belonging to the Anglo-Persian Oil Company, who have large works on this part of the Tigris. The Firefly was commissioned on November 2 following, and was the only one of the "Fly" gunboats which took part in the first expedition under General Townshend—when she was captured by the Turks, and later on retaken during the operations which resulted in the capture of Baghdad.

The re-erection at Abadan was under the direction of Mr. William Grant, a member of Messrs. Yarrow's staff, who, for this purpose, was appointed an Admiralty overseer. The King recognised the good work done by Mr. Grant in putting the vessels together with such rapidity, by conferring upon him the Order of the British Empire during His Majesty's recent visit to Glasgow. As might be expected,

* This vessel was fully illustrated in Engineering of November 6, 1914, vol. xcviii, p. 572.

there was great difficulty in finding suitable labour in such an out-of-the-way place. Men were drawn from all parts, Mr. Grant only being assisted by eight Europeans. The photographic group reproduced in Fig. 2, on page 429, gives an idea of the great variety of races represented among the workers. At one time there were 900 men employed, and they consisted of all sorts and descriptions of races and religions—Indians of different castes, some of whom were excellent workmen; Arabs; Persians of all denominations; Chinese, &c. The difficulty of so many races working together on one contract can be easily imagined, especially when it is considered that each race had its particular feast days and fasts; and, of course, their religious observances did not admit of being interfered with. Many had prayers at all hours of the day, when they could not be disturbed. At the beginning of the work some 40 Turks were discovered helping to put the gunboats together. Needless to say, they were very soon cleared out. It appeared that, provided the pay was good, their patriotism did not prevent them from working on vessels intended to operate against their own people!

Three vessels were laid down near the river, parallel to the bank, and three more were erected behind them, arranged to be launched sideways. The three next the river were finished first; after they were launched, those immediately behind were slid down on the ways to the positions vacated by the first three; then a third set of three were built behind; and so on until all were finished. Fig. 3, on page 442, shows three of the vessels thus in line, Fig. 4, one ready for launching, and Fig. 5, also on the same page, one launched. The last of the 12 gunboats was commissioned on March 11, 1916. Although the Yarrow firm were given a free hand in carrying out this contract, they received the cordial co-operation of the technical authorities at Whitehall.

In addition to the 12 "Fly" gunboats, there were four larger gunboats which also formed part of the expedition to Baghdad, viz., the Mantis, Moth, Tarantula and Gnat. These belonged to another flotilla of 12 ordered by Lord Fisher from the Yarrow firm simultaneously with those of the "Fly" Class. In this case the vessels were constructed by different firms, who worked from designs supplied by Messrs. Yarrow, thus ensuring uniformity throughout. They were 230 ft. long by 36 ft. beam, propelled by twin screws working in tunnels with Yarrow's hinged flap. They were riveted up in this country and navigated out to the Persian Gulf. Although designed for river navigation, and not intended to encounter rough weather, the voyage in all cases was successfully accomplished by these vessels.

The Scotstoun, referred to in Captain Nunn's report, was a flat-bottomed sternwheeler, fitted up as a repair shop, completely equipped with the necessary machines and tools, and was intended to follow in the rear of the flotilla so as to be available for the repairs found necessary from time to time. The vessels referred to in this article must not be confused with the many steamers placed on the Tigris at an early period of the war for transport purposes, these being obtained from various rivers in the East.

It must be very gratifying to Lord Fisher to see the success of the steps which he took to provide gunboats for the Tigris, and to obtain them quickly; and it proves the soundness of the policy adopted in entrusting a firm of repute with a free hand. The result of such a course appears to us, by the stroke of a pen, to have automatically increased the Admiralty staff at a time when they were overburdened with work; and we venture to think that this principle might be extended, under war conditions, to the benefit of the nation. The effect of its being known in a shipyard that the responsibility for an undertaking is left entirely in the hands of the firm, leads everyone, from the highest to the lowest, to strive their utmost in order to ensure success—a result which cannot be obtained if personal interest is not encouraged.

In allotting praise, which they so richly deserve, to those who took part in the naval expedition the authorities should not forget to show appreciation of the energy displayed by the workmen on the Clyde, who built this flotilla in six months and two days, for had they not put forth exceptional effort, the vessels could not have been finished in time to have taken part in the expedition, and in such case it is quite possible that Baghdad might not now be in our possession.

THE EFFECT OF INTRUSIVE WATER ON THE STABILITY OF A MASONRY DAM.

By A. A. Stoddard, D.Sc., Assoc.M.Inst.C.E.

The allowance to be made in the design of a masonry dam for the effect of water penetrating the foundation has been the subject of a good deal of discussion at various times. There has never seemed to be a very clear conception of the matter, but one of the two following opinions is commonly held—that allowance for the upthrust of water penetrating the base of a dam should be made on the assumption that it varies from an amount due to the full hydrostatic head at the up-stream toe, to zero at the down-stream toe; or, the up-thrust should be considered as being equal to that due to the full hydrostatic head over the entire base of the dam. In the design of the Vyrnwy Dam, for instance, allowance for this factor was made on the first of these assumptions. In Fig. 1 the hachured triangle A B C represents the distribution of the water pressure under the base on the first assumption, and in Fig. 2, which illustrates the other view, the up-thrust distribution is represented by the hachured rectangle A C D B, A C being the pressure due to the full head on the foundation in each case.

2. The first hypothesis appears to the writer to be utterly untenable, for it must necessarily imply a steady flow, or creep, of water under the base, escaping at the down-stream toe; no reduction of pressure could possibly occur otherwise. Furthermore, this creep must take place as a continuous sheet of water over the entire width of the foundation, localised flow, through foundation fissures only, could not affect the head of pressure anywhere else but in its immediate vicinity. If this occurred the dam would not be in contact with the foundation at all, for the foundation reaction cannot have two values at any one point at the same time, one due to the resultant of the weight of the structure and the pressure of the impounded water, and the other due simply to water pressure under the base. The total reaction from the foundation must be exactly equal to the total weight of the dam (and water resting on the up-stream face, if this is curved or battered), and it is manifestly impossible for this necessary relation to hold under the first assumption as to the distribution of water pressure under the base.

3. The second hypothesis might theoretically be realised in certain special circumstances, which will be indicated shortly. In general it can only be possible for water to penetrate the base joint up to a certain point, there can be no flow if the structure is stable (except along fissures, which, as just pointed out, does not concern the present argument), and the foundation pressure, from the up-stream toe to this point, must necessarily be uniformly equal to the full hydrostatic head at the up-stream toe. In Fig. 3, D is the limit of penetration, and up to this point the dam is not in intimate contact with the foundation, but is waterborne. Beyond the point D the structure must remain in contact with the foundation, and the foundation pressure must increase towards the down-stream toe in order that the total pressure may be equal to the weight of the structure. In the case of an actual dam it is quite impossible to determine the distance to which water might penetrate the base and so estimate its effect on the stability of the structure, for this must depend on the manner in which the base of the dam is bonded into the foundation, and on the cohesive strength of the foundation joints, amongst other factors. Only under the purely hypothetical conditions, never remotely realised in practice except when complete failure is imminent, of total absence of bond with the foundation and complete lack of adhesion along the base joint, is it possible to investigate the effect of an intrusion of water under the base. In these circumstances it would be possible for water to penetrate the base joint up to the point at which the vertical component pressure intensity due to all the applied forces became equal to the hydrostatic pressure intensity at the up-stream toe. Up to this point the dam would be water-borne and the foundation pressure would be uniform, as stated above; beyond this point it may be assumed that the pressure increases uniformly to a maximum at the down-stream toe. The distribution of the vertical component of the foundation pressures would be as shown by the hachured figure A B E D C in Fig. 3.

4. The following theory of the effect of intrusive water seems rational:—

In Fig. 3 let—

- b = width of base of dam.
- x = distance of penetration of water under base.
- a = horizontal distance of centre of gravity of dam, and the water resting on the up-stream face, if this is curved or battered, from the up-stream toe A.
- W = total weight of structure and water resting on the up-stream face.
- h = hydrostatic head at up-stream toe.
- p_w = intensity of pressure due to the head $h = w\,h$.
- p_1 = intensity of normal component of pressure at the down-stream toe.
- w = weight of unit volume of water.
- e = density of the dam material.

Then the total vertical pressure on the base A B is

$$p_w\,b + \frac{(p_1 - p_w)}{2}(b - x) = \frac{1}{2}\left\{p_w(b + x) + p_1(b - x)\right\}.$$

This must necessarily equal the total foundation load W.

$$\therefore\ p_w(b + x) + p_1(b - x) = 2\,W$$

whence
$$p_1 = \frac{2\,W - p_w(b + x)}{b - x} \quad . \quad . \quad . \quad (1)$$

The moment of the total base reaction about the toe A is

$$p_w\frac{b^2}{2} + \frac{p_1 - p_w}{2}(b - x)\left(b - \frac{b - x}{3}\right) =$$

$$\frac{p_w}{6}(b^2 + b\,x + x^2) + \frac{p_1}{6}(b - x)(2\,b + x).$$

For equilibrium, this must be equal to the sum of the moments of the total horizontal thrust of the impounded water and the weight of the structure W, which latter will include the water resting on the up-stream face, if this is battered, about the same point, *i.e.*:—

$$\frac{w\,h^3}{6} + W\,a = \frac{p_w}{6}(b^2 + bx + x^2) + \frac{p_1}{6}(b - x)(2\,b + x).$$

Substituting, in this expression, the value of p_1 given by equation (1) and for p_w putting its value $w\,h$, the equation reduces to

$$x = \frac{w\,h\,(b^2 + h^2) - 2\,W\,(2\,b - 3\,a)}{2\,(W - w\,b\,h)} \quad . \quad . \quad (2)$$

In any given case the possible distance of water penetration can be determined from this last expression, and, on substitution in equation (1), the vertical-pressure component at the down-stream toe, *i.e.*, p_1, is arrived at. If the determination of the necessary width of base required to limit the maximum pressure component p_1 to a previously chosen intensity is desired, W and a must be known, or approximately known, in terms of b and h, and then the base width required can be evaluated from equations (1) and (2).

5. To simplify matters, consider a dam of approximately triangular section with a vertical back, which most modern dams practically are, or are tending to become, then

$$W = \frac{e\,w\,b\,h}{2};\ \text{and}\ a = \frac{b}{3}$$

Equation (2) reduces to

$$\frac{x}{b} = \frac{\left(\frac{h}{b}\right)^2 - e + 1}{e - 2} \quad . \quad . \quad . \quad (3)$$

Equation (1) reduces to

$$\frac{p_1}{w\,h} = \frac{e - 1 - \frac{x}{b}}{1 - \frac{x}{b}} \quad . \quad . \quad . \quad (4)$$

Substituting the value of $\frac{x}{b}$ given by equation (3)

$$\frac{p_1}{w\,h} = \frac{(e - 1)^2 - \left(\frac{h}{b}\right)^2}{(2\,e - 3) - \left(\frac{h}{b}\right)^2} \quad . \quad . \quad (5)$$

or,

$$b = h\sqrt{\frac{\frac{p_1}{w\,h} - 1}{(2\,\epsilon - 3)\frac{p_1}{w\,h} - (\epsilon - 1)^2}} \quad . \quad . \quad (6)$$

6. These formulæ enable us to realise what the effect of intrusive water would be, if its access to the foundations were unimpeded. First of all, the case of $\epsilon = 2.0$, the dam being of triangular section, or approximately so, is especially interesting.

In this case

from (6), $b = h$
,, (5), $p_1 = w\,h$
,, (3), x is indeterminate.

The meaning of these results is that, if the base width is less than the height h, equilibrium is impossible if water has free access to the base, the dam must overturn. If the base width is equal to h, the dam would be in neutral equilibrium—water might penetrate the base to any distance or might not penetrate at all. The pressure would be uniform over the whole base in any event, whether water intruded or not, its intensity being equal to $w\,h$ and quite independent of the base width, even if this were less than h and the dam overturning. All this is really obvious at first sight in this particular case, but its deduction from the above theory is an interesting confirmation of its rationality.

In general, when ϵ is greater than 2.0 (it is never less in practice), and the ratio $\frac{x}{b} = 1.0$, *i.e.*, intrusive water extending over the entire base, it is obvious from equation (4) that the pressure at the down-stream toe p_1 must suddenly change from $w\,h$ to an infinitely great intensity. This state of affairs would theoretically occur when the base width $b = \frac{h}{\sqrt{2\,\epsilon - 3}}$, as given by equation (3), putting $x = b$.

For any smaller value of b stability could not be obtained, quite apart from the possibility of the masonry being crushed at the down-stream toe under the high intensity of pressure.

7. It seems quite clear, then, that it is irrational to assume that a dam can be subjected to up-thrust, from intrusive water, of uniform intensity over the entire base, for there is only one ratio of base width to height, with a given density of dam material, which could render this state of affairs theoretically possible, and with this base width the structure would not be stable.

For example, take $h = 250$ ft. and $b = 204$ ft., the dam section being approximately triangular.

First, take $\epsilon = 2.5$, a very usual value.

Then, from equation (3), $x = 0$.

With this density of the dam material, water could not penetrate the base joint at all.

Next take $\epsilon = 2.25$,

Then, from equation (3), $x = 1.0$.

In this case, if water had free access to the foundations, the dam would fail by crushing of the masonry at the down-stream toe and overturning.

This example shows the enormous influence which a slight variation of the density of the dam material would exercise on its stability, if water could intrude to this theoretically possible extent.

8. It is interesting to compare the base width necessitated by compliance with equation (6) with the width b_1 say, required to induce the same intensity of the vertical pressure component p_1 at the down-stream toe, in the absence of intrusive water.

For this, in Fig. 4, let

b_1 = width of base of dam,
y = horizontal distance of point of application of resultant pressure on the foundation from the up-stream toe,
p_m = mean intensity of normal pressure on the foundation,

all other symbols having the same meaning as in the foregoing.

Taking moments about the point of application of the resultant, for equilibrium

$$\frac{w h^3}{6} = W\,(y - a); \text{ or, } y = \frac{w h^3}{6\,W} + a$$

$$p_m = \frac{W}{b_1}$$

and $$p_1 = 2\,p_m\,(3\,\frac{y}{b} - 1),$$

with uniformly varying stress.

$$\therefore p_1 = \frac{2\,W}{b_1}\left(\frac{w\,h^3}{2\,W\,b_1} + 3\,\frac{a}{b_1} - 1\right)$$

$$= \frac{1}{b_1^2}\{w h^3 - 2\,W\,(b - 3\,a)\}$$

In this last expression the term containing W is always small in a rationally designed dam, and for present purposes, since we are considering a dam of approximately triangular section, we may take $b = 3\,a$.

Then, in the absence of intrusive water,

$$p_1 = \frac{w h^3}{b_1^2} \text{ or, } \frac{p_1}{w\,h} = \left(\frac{h}{b_1}\right)^2$$

Substituting this value of p_1 in equation (6) gives

$$b = h\sqrt{\frac{\left(\frac{h}{b_1}\right)^2 - 1}{(2\,\epsilon - 3)\left(\frac{h}{b_1}\right)^2 - (\epsilon - 1)^2}} \quad . \quad . \quad (7)$$

$$b = b_1\sqrt{\frac{\left(\frac{h}{b_1}\right)^2 - 1}{(2\,\epsilon - 3) - \left(\frac{b_1}{h}\right)^2(\epsilon - 1)^2}} \quad . \quad . \quad (8)$$

Taking $b_1 = 204$ ft. and $h = 250$ ft., as before, from equation (8)

$b = 212$ ft. with $\epsilon = 2.25$,

and from equation (3)

$x = 0.56\,b$; $= 119$ ft.,

$$p_1 = \frac{62.5}{2240} \times \frac{250^3}{204^2} = 10.5 \text{ tons per sq. ft.}$$

9. The results just found serve to show how very small is the margin between safety and complete failure of the structure if it were possible for water to creep under the base to the extent indicated by the above theory, which could only occur under the assumed conditions of total absence of foundation bond and cohesion. Under these conditions it has been shown that, in the particular example chosen, the down-stream toe would crush under the high local intensity of stress at that point, water could intrude over the entire base, and the dam would overturn if its base width were only 204 ft., while an increase of width of only 8 ft., or 4 per cent., suffices to limit the maximum intensity of the normal pressure component to a safe amount.

10. In actual practice, with a dam built on sound rock, the foundation bond and the cohesive strength of the base joint prevent the intrusion of water to the extent which would certainly be possible in the complete absence of these factors. The danger of its occurring to a certain degree is nevertheless very real, in view of the discovery of the existence of high tensile stresses at the up-stream toe, arising out of recent researches (*vide* Proc. I.C.E., vol. clxxii), and it is of the highest importance that either the base be made wide enough to entirely eliminate this source of danger, or means be provided for draining any seepage taking place to the tail water. The latter alternative is the one most commonly adopted in modern practice, the precautions taken in the recently completed Kensico Dam, in this respect, furnishing a good example.

11. The base width required to prevent all seepage, other than the almost unavoidable creep through local foundation fissures, which is harmless on a generally sound rock foundation, is at once found from equation (2) in the general case, or equation (3) in the case of a dam of approximately triangular section, by putting $x = 0$. Thus, from (3), when $x = 0$,

$$b = \frac{h}{\sqrt{(\epsilon - 1)}} \quad . \quad . \quad . \quad . \quad (9)$$

It is easily seen that this is the width required to make the normal pressure at the up-stream toe equal to the water pressure. For, if p_0 = normal pressure intensity at the up-stream toe, then,

$$p_0 + p_1 = 2\,p_m = \frac{2\,W}{b} = \epsilon\,w\,h$$

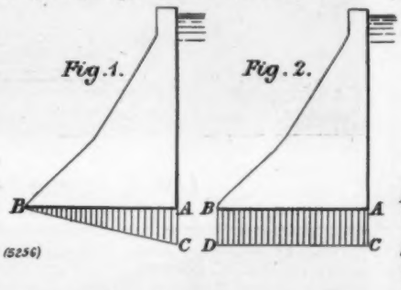
for triangular section.

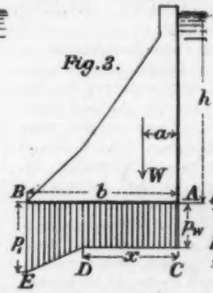
$$\therefore p_0 = \epsilon\,w\,h - \frac{w\,h^3}{b^2}$$

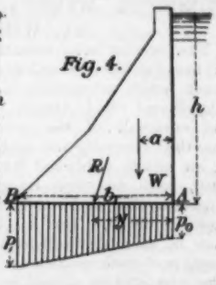
On substituting for b its value given by equation (9), we find $p_0 = w\,h$.

Applying this to the example taken above, the required width is found to be 223 ft., which is only about 9¼ per cent. in excess of the width at which the dam would fail if all foundation bond and cohesion were lacking.

12. The foundation joint is not the only part of the structure which might be subjected to the up-thrust of intrusive water; of course this might happen anywhere if conditions permitted it, such as the existence of a more or less horizontal fissure in the up-stream face caused by temperature effects or faults of design and construction. The failure of the Bouzey Dam in 1895, for instance, was undoubtedly due to faulty design and the use of poor materials in construction, in the first place. The density of the material of this dam was little more than 2.0, and at the level of the plane of failure the up-stream face was under tension amounting to 1¼ tons per square foot before the opening of the fissure which was the immediate cause of failure







(*vide* Proc. I.C.E., vol. cxxvi, page 93), and once the fissure started it is easy to appreciate how great the effect of the water penetrating it would be. In order to entirely eliminate this source of danger M. Lévy has suggested that the dam section should be everywhere wide enough to cause the vertical pressure component at the up-stream face to be at least equal to the hydrostatic pressure at the same level (*Comptes Rendus de l'Academie des Sciences*, 1895 and 1898; *Annales des Ponts et Chaussées*, 1897). In the case of a dam of approximately triangular section, if this principle were adopted, the width of section would require to have the value given by equation (9) as a minimum; that is, until the height of the dam becomes sufficiently great as to necessitate a still greater width in order to restrict the maximum principal stresses induced at the down-stream toe to safe intensities. The usual rule governing the width adopted for the upper part of a high dam where, in modern practice, the up-stream face is quite vertical is the well-known one $b = \frac{h}{\sqrt{\epsilon}}$, with which width the resultant pressure on a horizontal plane falls exactly on the outer middle third. The width of section required by compliance with formula (9) is therefore, roughly, 13 per cent. in excess of that adopted in usual practice, with the density of the dam material lying between the values 2.25 and 2.5. This would mean a very appreciable enhancement of the cost of the structure, and in high and large dams the most economical method of thoroughly safeguarding the structure from the effects of intrusive water would generally lie in the provision of an efficient drainage system near the up-stream face, throughout its whole height, connecting with cross-drains leading to the tail water, as exemplified in the Kensico Dam.

13. A question apart from the possible intrusion of water under the base of a dam and into cracks elsewhere in the up-stream face is that of the presence of infiltrated water in the interstices of

the dam material. It is a matter of common observation that many dams show signs of sweating on the down-stream face. This is most marked while the dam is still green, and, as a rule, as the structure ages the action ceases or becomes scarcely perceptible. There are cases, however, of a persistence of this sweating in old dams. The uplifting effect of this interstitial water cannot be estimated with any degree of accuracy, but it is obvious that it must be practically negligible. The sweating shows that there is a very slow and minute flow of water through the dam from face to face; the pressure at any level must therefore decrease in a practically uniform manner from that due to the hydrostatic head at the up-stream face to zero at the down-stream face. Also, since all the material lying above the level considered is saturated with water, its density is increased, and as the dam section is practically triangular, the centre of gravity of the interstitial water practically lies directly over the resultant up-thrust. The difference between the amount of the uplift and the weight of infiltrated water contained above any plane considered will depend on the shape of the voids in cross-section, but if the balance lies in favour of the uplift, it must be negligibly small.

14. In conclusion it is hoped that the foregoing attempt to obtain a clear picture of the possible action of intrusive water and of its bearing on the design of a masonry dam will prove to be useful.

TUNGSTEN MANUFACTURING WORKS AT WIDNES.

New works have recently been established in Widnes for the production of tungsten, on a scale never before attempted in this country, by the High-Speed Steel Alloys, Limited, formed since the outbreak of the war. These works were described generally and their *raison d'être* reviewed in an article published by us on November 24, 1916, and we now return to the subject to illustrate the works and describe the processes more in detail. But by way of introduction it may be said that tungsten enters into the composition of steels used for a large number of purposes. The consumption of tool steel to-day is enormous, and attempts to improve its quality by varying the composition of the alloys are unending. It still remains true, however, that no other alloy has equalled the tungsten-vanadium steels for all purposes for which tool steel is used, notwithstanding the claims put forward for certain special alloys. Ordinary high-speed tungsten steel can do work for general purposes that other steels are unable to do with the same satisfactory results. Further, tungsten steels can be remade time and again, as they are forgeable, but many of the new alloys can only be cast and ground to shape, and must be remelted when worn. These facts show the importance of the establishment of a permanent tungsten powder factory in this country. The raw material worked up is wolframite, an ore consisting of tungsten, iron, manganese and oxygen, or tungstate of iron and manganese, frequently associated with tin ores. The ore supplies, coming possibly from the same deposits, or from different localities, vary considerably in composition; constant work in the laboratory is therefore necessary to modify the processes in order to deal with the variations, so as to maintain the final output of a constant quality. As the degree of purity attained is 99 per cent., or only just below absolutely pure tungsten, continuous laboratory supervision is all-important.

When the war broke out the site of the works was waste ground, with the exception of a small building and a chimney; since the summer of 1914 the large group of buildings shown in Figs. 1 and 2, has been erected on a six-acre site. These are filled with complicated mechanical appliances, the workpeople have been trained to new and varied duties, and an uninterrupted output has been maintained. Extensive railway sidings are laid, but at present motor lorries are employed for the dispatch of the finished product to the works of consumers, whose urgent need of tungsten makes the inevitable delay of railway transport serious. The company, it may be said, has not overlooked the comforts of the workpeople, both men and women, some of the processes being carried out by girls. Messrooms for the convenience of both have been provided. All the buildings are lofty and well ventilated and lighted, and none of the processes, nor any of the work, can be described as in any way unhealthy. A notable point is the absence of dust, although the processes are such as to give rise to large quantities; all plant producing it is enclosed. A repair shop is included among the buildings, consisting of a smithy and engineers' and joiners' shops, and a large block of offices facing the main road accommodates the management.

Fig. 1. Exterior View of Portion of the Works.

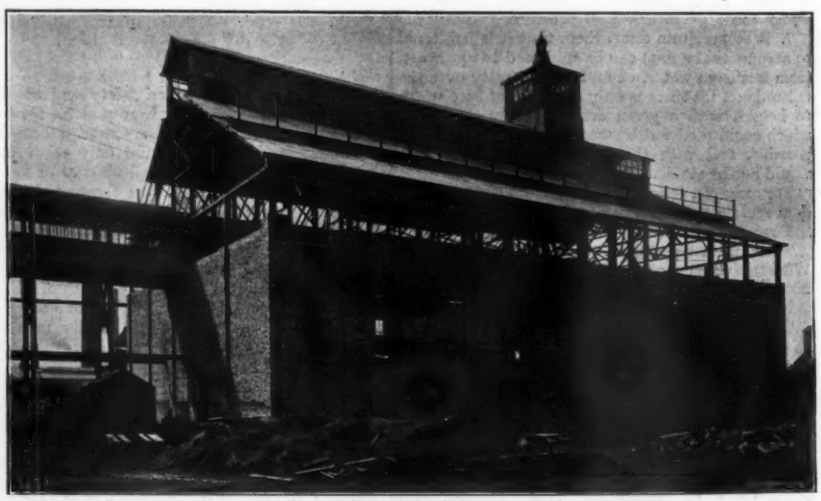


Fig. 2. Recent Extension.

All the processes are arranged on the ground-floor level, but some of them extend upwards as well, and are reached from several floors. Taking the processes in their order, the trucks bringing the ore, soda and other requisites are run alongside a staging in the warehouse, arranged at a convenient height for unloading, the wagons being handled by the company's locomotive crane. The ore is received broken into small cubes, which would readily pass through an inch mesh; it consists of tungsten oxide and waste material, and it has to pass through eight operations, each carried out in a separate department of the works. Of these eight operations six are necessary to isolate or separate the tungsten oxide from the other constituents of the ore (Fig. 3), and the remaining two operations to remove the oxygen, so as to obtain the pure metal. Some ores contain tin or bismuth of sufficient value to be recovered, and this is effected by magnetic separators, wolfram being slightly magnetic. The first step is to sample and assay the ore, which then is loaded into small trucks and elevated to a series of bins some 60 ft. above floor-level. Parcels of ore requiring different methods of treatment are kept separate. From the bins the ore passes to grinding machines, and thence to calcining furnaces, magnetic separators or fine grinding mills, as its composition may require.

Only wolfram, finely ground and ready for treatment, passes forward to the regular process; and impure or mixed ores, which cannot be improved by mechanical or magnetic methods, go to a special department referred to later. The pure wolfram thus obtained is conveyed in trucks to bins placed over mixing machines, adjacent to a supply of soda. The finely ground ore and the soda, in accurately weighed proportions determined by analysis in the laboratory, are then fed into double-arm mixers, and the mixed product is discharged into trucks for conveyance to the melting furnaces, in which is performed operation two in the works department "B."

Scheelite, that variety of ore consisting of tungsten, calcium and oxygen, also known as calcium tungstate, as well as mixed wolfram-tin slimes, tin residue mixed with small quantities of

tungsten ore and residues of other sorts, are treated in a separate plant, so that impure sodium tungstate may be isolated and purified before being passed on to the main process.

The next building contains a series of hand-fired reverberatory furnaces of special design, into which the ground ore and soda are fed and heated to a temperature of about 1,000 deg. C. and in a solid lump, which is easily broken up by hammers to a size suitable for feeding a jaw breaker, in which the lumps are reduced to about 1-in. cubes. The melt produced is a great contrast to the fine powder fed into the furnaces. After having been broken up it has to be finely ground in order that it may be acted upon by the chemicals, these processes forming the third operation, carried out in depart-

Fig. 3. Preliminary Preparation Process.

Fig. 4. Final Washing of the Metal.

subjected to constant rabbling. The furnaces just mentioned are designed to economise floor space; they are fed on one side with ore and are stoked from the opposite side. Flues below the floor connect the furnaces with a centrally-placed chimney, 150 ft. in height and 9 ft. in diameter. Ore mixtures are carefully selected, so far as the restricted supply permits, to yield a uniform furnace product, and the charge is drawn into slag pots, which are wheeled to a convenient point for handling by an overhead electric travelling crane. These pots, when cool, are raised and tipped, the charge coming away

ment "C." The material is handled by an overhead crane, and the main shafting is run under the floor, to give the crane a free passage.

In the fourth process, in the "D" department or building, the finely ground melt is placed in a number of steam-heated circular vats, in which the tungstate of soda, which is soluble, due to the soda, is extracted from the ground furnace melt. Mixers are provided in the vats, and the solution of sodium tungstate, carrying in suspension finely divided oxides of iron, manganese, lime and silica, is forced through filter presses. The resulting solution thus clarified contains essentially sodium tungstate, the purity of which depends upon the absence of sulphur, arsenic and other elements, which form soluble compounds with soda. Tin oxide, which occurs in many of the ores, under correct working conditions does not become soluble, and remains in the filter cake. The steam required for the "D" department is obtained from an adjoining boiler-house, containing two Lancashire boilers.

In the "E" department the fifth process is effected in a series of special vats on a raised platform. The tungstate of soda is treated with hydrochloric acid, which is elevated by compressed air, and results in the tungstate of soda being broken up into tungstic acid (WO_3) and sodium chloride, which remains in solution. The solution, with the WO_3 in suspension, is conveyed to another series of vats, in which it is washed by decantation, to rid it of the soda salts. As much water as possible has to be got rid of, and after the final wash the WO_3 is brought to a creamy consistency by the surplus water being siphoned off. This cream is then conveyed to a number of centrifugal machines, in which the WO_3 collects along the inner face as a thick, deep chrome-yellow paste. It is dug out with wooden spades and finally dried in a series of bottom-heated stoves. This drying process is the sixth, and is effected in the "F" department. The chemical processes may now be described as completed, as all that remains to be done is to obtain the pure metal from the oxide, which is an ordinary metallurgical operation involving only heat and the presence of a suitable reducing agent, such as carbon, hydrocarbons, hydrogen, zinc, aluminium or others.

The seventh process, in the "G" department, is effected in a large roomy building containing a number of specially designed furnaces. The yellow paste is passed into the end of each furnace and raised to a high temperature to effect reduction, and the metal is thus obtained. The output of these furnaces is a black material, which is conveyed into the last, the eighth (Fig. 4), of the series of buildings, where it is ground to a powder, washed, dried and poured into tin cases about 1 cub. ft. each in size, containing 200 lb., and finally, after soldering, packed in wooden boxes or metal containers, ready for conveyance to the consumers.

Six of these processes could be avoided and saved if tungsten oxide (WO_3) could be found in a natural state in quantity. It does occur, as a matter of fact, but in minute quantities, through local decomposition of wolfram or scheelite, and it may be regarded as a mineral curiosity. There is a specimen of it in the laboratory of the High-Speed Steel Company's works, a bright yellow lump, apparently rather brittle or friable. The works of the High-Speed Steel Alloys, Limited, are capable of turning out daily 3 tons of pure tungsten in the form of a heavy grey powder, providing ample supplies of ore are received. This output is essential for the production of high-speed steel, of which tungsten forms 18 per cent. to 20 per cent. The quality of the steel is impaired if various impurities occur in the tungsten in quantities above a certain minimum. It is of the utmost importance, therefore, that the output of the works at Widnes should be as nearly pure as possible, otherwise the steel produced and the melting, forging and rolling would be adversely affected, resulting in the efficiency of the finished product being materially reduced. The degree of purity attained at the Widnes works is greater than that of the German-made metal imported before the war, when there was no output in this country.

Our supplies from abroad having been cut off, and the stock of this all-important constitutent of high-speed steel being limited, the Government instituted an inquiry into the supply and the means of obtaining adequate quantities. The possibilities of ferro-tungsten were investigated. It was then decided that a factory to produce tungsten metal powder was essential, and the Government sanctioned the erection of a works by the makers of high-speed steel, at the same time offering financial assistance. The factory erected is that described above. A committee of high-speed steel makers took the work in hand and engaged the services of Mr. J. L. F. Vogel, son of the late

Hon. Sir Julius Vogel, K.C.M.G., formerly Premier of and Agent-General for New Zealand, who had acquired practical experience in making tungsten metal powder in a small factory in London some years ago. To start and establish the enterprise a company was registered in the ordinary way, and every maker of high-speed steel had an opportunity of taking up shares in proportion to his average requirements; some thirty firms, whose combined output of high-speed steel prior to the war ranged from 70 per cent. to 80 per cent. of the total output of this country, supported the new undertaking and contributed to the capital required.

The ferro-tungsten mentioned above is obtained from the ore by removing the oxygen from the combined oxides, this leaving an alloy of tungsten and iron. This ferro-tungsten was produced chiefly in France, but now it is made extensively in this country. It differs from the output of the Widnes factory in so far that, whilst in separating the tungsten oxide (WO_3) from the ore all impurities can be eliminated, in the smelting of ore direct these are, to a certain extent, retained, so that only high-grade ores can be used as a source for ferro-tungsten, and even then impurities cannot be eliminated altogether.

On September 1, 1915, the Government took control of all tungsten ores within the British Empire, and as the supply has not been equal to the demand, it has been equitably divided between the makers of tungsten and ferro-tungsten. To enable the output of wolfram ore within the British Empire to be increased, the High-Speed Steel Alloys Company, after establishing their works in Widnes, purchased mines in Burma, and sent out Dr. W. R. Jones, formerly attached to the Indian survey, to take charge of and to develop them. A completely equipped laboratory and magnetic separation plant have also been sent out, and a carefully selected staff of mining engineers, chemists and accountants are now at work at the company's establishment in Tavoy. That the largest producers of high-speed steel, who are themselves in many cases among the largest consumers, believe in the permanence of tungsten-making as a basic industry is clearly shown by the way in which they have established this factory. It has been erected not to last for the duration of the war only, but to form a weapon in the industrial war foreshadowed. Where improvements to effect economy in manufacture have been worked out they are being introduced as quickly as circumstances allow, and while tungsten steel continues to hold its own against all competing alloys for tool-making, as it does undoubtedly at present, this factory should lend no inconsiderable assistance in post-war efforts to retain the markets of the world for British-made high-speed steel.

Graphite Remedy for Boiler Scale.—A very finely powdered graphite placed in a boiler immediately after it has been cleaned circulates with the water and rubs against the steel, to which it imparts a graphite polish on which scale does not readily form, says *Power House*, Toronto. When the initial quantity is regularly followed up by smaller ones, the graphite by mechanical action gradually softens and disintegrates any old scale that may still be present, and if new scale thereafter forms, and it almost always will to some extent, it forms in and with that scale, so that all may be easily broken up and removed. Inferior grades cannot with safety be allowed in steam boilers. The graphite mined in Mexico is said to be the best for steam boilers.

Potassium Compounds.—The Minister of Munitions has ordered that no person shall, as from the 17th inst., until further notice, offer to purchase any potassium compounds as defined further on, except in accordance with the terms of a licence issued by the Controller of Potash Production, or offer to sell any such potassium compounds to any person other than the holder of such a licence; provided that no such licence shall be required by the Admiralty or War Office, or by any person for the purchase and delivery of potassium compounds in quantities not exceeding in weight an aggregate of 3 lb. avoirdupois during any one calendar month. Returns of potassium compounds are to be furnished to the Controller. The potassium compounds to which this order relates are caustic potash (KOH), chloride or muriate of potash (KCl), carbonate of potash (K_2CO_3) and sulphate of potash (K_2SO_4), whether in a pure or in a commercial form, and any material (other than blast-furnace dust referred to in the Order of the Minister of Munitions of August 7, 1917) of which more than 10 per cent. consists of any one or more of the above. All applications in reference to the above Order to be addressed to the Controller of Potash Production, Ministry of Munitions, 117, Piccadilly, W. 1.

HANDLING MATERIALS AUTOMATICALLY WITH SKIP HOISTS.*

By H. V. Schiefer.†

The skip hoist has long found favour as a machine for handling granular materials. The introduction of the automatic slow-down and discharge gave it a permanent place among material-handling machines. Now we have a skip hoist that is entirely automatic in its functions. In other words, we can place a railroad car of material over a track hopper, open the gates of the car, and in a short time return and find a large quantity of material automatically transferred to an overhead bin without even the services of an attendant; in fact the doors of the hoisting engine-house are usually kept locked excepting when the plant electrician or oiler inspects the equipment, say once a day.

A skip hoist may be described as a bucket (usually called a skip) that travels up and down a runway by means of a cable wound over a drum of a hoisting engine. From the nature of the machine the only parts subject to wear are the wheels of the skip bucket, the cable and the hoisting engine itself. The wheels are made of chilled cast-iron or steel, and of such size as to reduce the wear to a minimum. The hoisting engine gears run in oiltight gear cases, thereby reducing wear. The hoisting ropes will last a long time, and when they need renewing they can be replaced quickly at a moderate cost.

In the past a bucket elevator or an inclined conveyor has been used to elevate materials in bulk. The limitations of an inclined conveyor are such that it cannot be inclined more than the natural angle of repose of the material handled without the introduction of flights or buckets, in which case the conveyor becomes an inclined elevator. Thus to elevate materials to, say, 100 ft. with a conveyor, a considerable amount of ground space is required, and also a very expensive belt or chain. Both of these are serious objections to the average plant manager, the first being that where a conveyor is installed the ground is usually valuable and cluttered up with other machinery, buildings, tracks, &c. The objection to a chain or belt is, of course, the high maintenance charge.

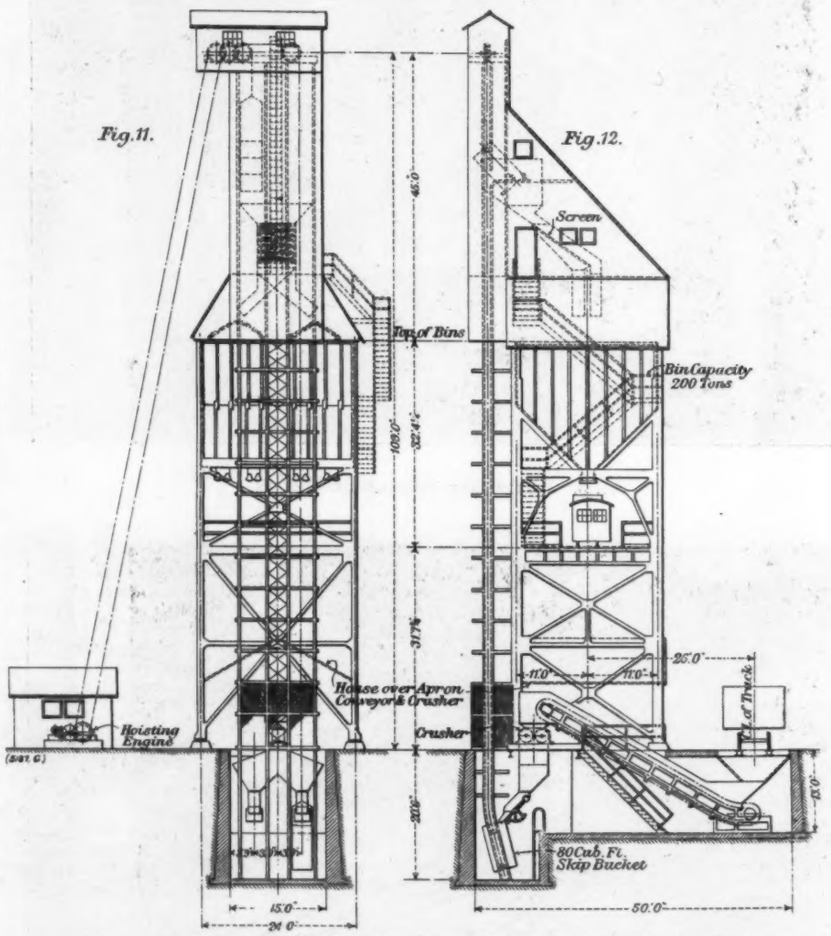
When comparing an elevator with a skip hoist I do not wish to convey the idea that all elevators should be replaced with skip hoists. The elevator and the conveyor have their places and the skip hoist has its adaptations. For small capacities and medium lifts the skip hoist cannot compete with the elevator; neither can it compete for large capacities with medium lifts, say 75 ft., with easy-flowing non-abrasive materials such as grain.

The field for the skip hoist is broad. It has not been thoroughly developed, but with the introduction of the automatic features it is getting immediate recognition and favour. In mines, quarries and rock-crushing plants the advantages can be readily seen. Large sums of money have been expended in trying to hoist coal from mines with bucket elevators instead of the usual method of hoisting the mine cars to the surface by means of a hoisting engine operated by a high-priced engineer, necessitating expensive safety devices, cage loaders, &c. The automatic skip hoist lends itself admirably to such a case. The mine cars could be dumped at the bottom of the mine directly to the automatic skip, which would take care of the hoisting automatically. The height to which a skip hoist can elevate material runs into thousands of feet, and it is this feature that makes a skip hoist successful in handling coal from a mine where an elevator would fail. The maximum height to which an average elevator can be used economically is something under 100 ft.

In quarries, rock-crushing plants, sand and gravel plants, &c., skip hoists are used to advantage, the points of advantage being that the material is carried in a bucket and does not come in contact with moving parts of the equipment. In handling gritty or abrasive materials this point is the one that makes the skip hoist desirable.

The greatest use of the automatic skip hoist at the present time is the handling of boiler-house coal, coke, ashes, in steel mills, limestone, flue dust, slag in power-houses, &c. It lends itself to almost any condition, and can be installed at any angle from about 15 deg. up to 90 deg. to the horizontal.

The skip hoist does not operate continuously, but only when material is fed to it. This is a point of advantage if one must compare the skip hoist with an elevator or conveyor. There are very few instances in which materials are handled continuously, there being times when an elevator or conveyor would run empty if an operator did not shut them off. Not so with an automatic skip hoist.



Figs. 11 and 12. Plant for Loading Run-of-Mine Coal into Railway Cars.

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* Paper read before the Cleveland (U.S.A.) Engineering Society.

† Engineer for C. O. Bartlett and Snow Company, Cleveland, Ohio, U.S.A.

When considering the workman's protection the automatic skip hoist offers the last word in "safety first," since there are no operators, therefore no accidents to workmen. In other words, it is fool-proof. The most serious accident that can happen to a skip hoist is the parting of a cable or the slipping of a brake on the motor, both of which are rare occurrences, and the result is simply a dented bucket bottom.

General Construction.—There are three general types of skip hoist construction, as follow :—

1. One skip bucket with counterweight.
2. One skip bucket without counterweight.
3. Two skip buckets in balance.

Practically all skip hoists are included in the above types. Any one of these types allows for the application of entire automatic or semi-automatic control. When we speak of an entirely automatic skip hoist we imply one that performs all of its functions without human assistance, one that loads, starts, hoists and discharges entirely by means of an electrical controlling device. A semi-automatic skip hoist is one that hoists, discharges and returns, or that hoists and discharges automatically but does not load or start automatically.

Entire Automatic Control.—An entirely automatic skip hoist requires that there be a storage hopper from which the material is delivered to the skip buckets. This storage hopper need not be large. If, for example, the skip hoist is being fed by a conveyor the storage hopper need be only large enough to hold material from the conveyor until the skip bucket has made a round trip. This may not even be equal to the capacity of the skip bucket. There is no limit as to the other extreme in size. The entire automatic control is most frequently used where the material is of a free, flowing nature, and also where it is required to hoist a regular quantity to a given height. It is impossible to get a real automatic control handling a material that is sticky. It is absolutely necessary that the material flow easily and quickly through a gate of nominal size. This type of hoist is particularly adapted to such materials as coal, sand, gravel, crushed stone, crushed slag, fine ore, &c., in short, any free-flowing material in which the lumps do not run much over 6 in. or 8 in. in size for ordinary capacities, say 200 tons per hour maximum. With larger capacities larger lumps can be handled.

The receiving or storage hopper is usually made of steel, and when using two skip buckets in balance it requires to be double, each half being fitted with a chute provided with a gate and arranged to deliver into the skip buckets. The gates are so designed that they will automatically be closed except when the skip bucket is in position to receive material. If enough material is contained in the storage hopper to fill the skip bucket, it automatically starts, and continues operating until there is not enough material left in the hopper to fill the skip bucket, in which case it automatically stops.

To fully describe the entire automatic system let us assume first of all that ore is to be elevated from a track hopper by means of skip buckets to an overhead bin. Assume an empty bucket at the bottom under one of the track hopper gates, the companion bucket having been hoisted to the top position in the proper location for dumping. The bucket which is in the lower position will have opened on its downward travel the gate of the chute from the track hopper, thus permitting a flow of ore from the track hopper into the skip bucket. As soon as the bucket is sufficiently loaded its weight raises the counterweight, which automatically closes the gate of the chute leading from the track hopper, thus stopping the flow of ore into the skip bucket. In addition to closing the gate it also operates an electric switch, which admits current to the hoisting engine motor. The skip bucket then starts upward slowly and, after a short period of time, by means of the automatic control system, the motor is accelerated and the bucket travels at full speed until it nears the top or dumping position, at which point the slow-down resistance is inserted, and at the proper moment the power is cut off from the motor and the solenoid brake applied, thus bringing the bucket to a stop in the dumping position, the other bucket being in the lower or initial position, ready to repeat the cycle of operation.

Figs. 1, 2 and 3, Plate XL, show a plan and sectional views of a flue dust sintering plant in which a full automatic skip hoist was the deciding factor in the design of the plant. There are ten overhead bins, in which five different kinds of materials are to be stored. One skip hoist is used in connection with a long swivel spout that is manipulated by hand so that it discharges into the proper spout. This is a single-bucket skip hoist which is run in conjunction with a counterweight. The rope that holds the bucket is threaded up over the house and down the opposite side to the hoisting engine drum. Another rope leaves the drum from the opposite side and leads up over a sheave to the counterweight. The hoisting engine house and counterweight show prominently in Fig. 4, which is an exterior photograph of the plant that is shown in outline in Figs. 2 and 3.

Fig. 5 shows a mechanical control system consisting of a set of counterweighted levers in the skip hoist pit, placed in such manner that the skip bucket rests on the short end of the arm and the weight of the empty skip bucket is insufficient to raise the counterweight. The bucket is provided with a pair of lugs A, one on either side of the bucket. As the bucket descends it is slowed up by the electrical control. It is not until the bucket has slowed almost to a stop that the lugs on the bucket strike a pair of rollers B that are attached to an undercut quadrant gate. This gate is pulled open until the latch C is engaged and prevents closing until the latch is released. The bucket then sinks on for a few inches farther, coming to a rest on the counterweighted levers. Material in the meantime has started to flow into the bucket, and continues to do so until the weight of the material is such that the counterweight D rises. The counterweight in rising pulls open the latch C, which has all the while held the gate open. The gate immediately closes, being actuated by counterweights E. The counterweight D, when rising, pulls the rope F, which is connected to a starting switch which admits current to the hoisting-engine motor and the bucket starts on its upward journey.

Should the electric power be cut off the gate would close, the bucket would stay at the bottom, and no material would spill into the pit. In some of the earlier types of automatic skip hoists the latch was not employed, the gate being held open by the lug on the bucket. With the power cut off, gate open, and no attendant, the

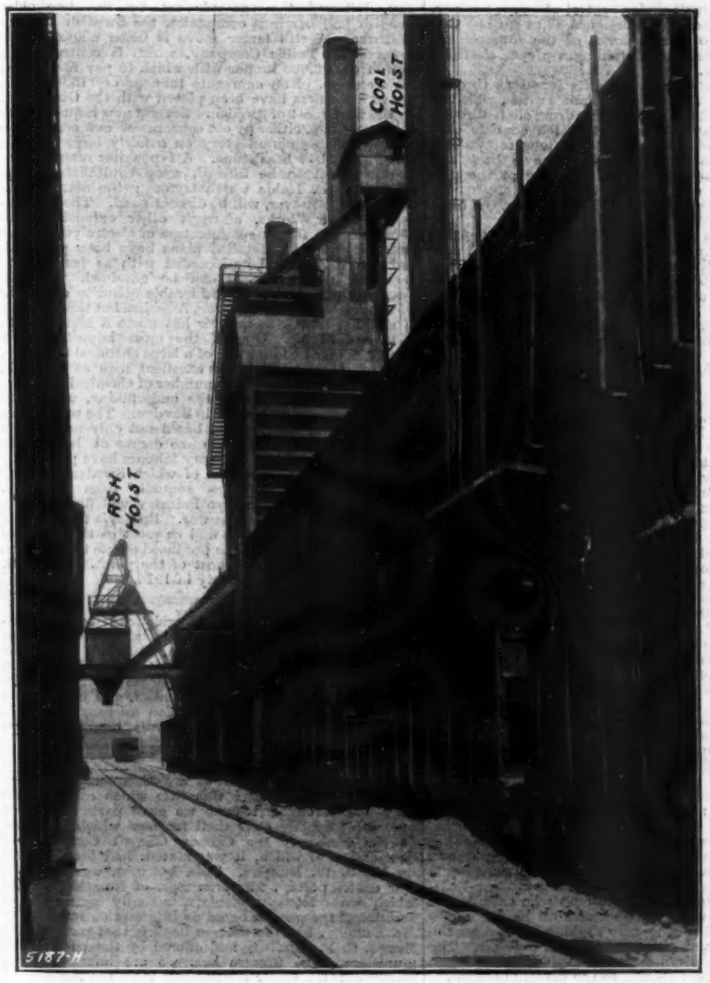


FIG. 13. STORAGE BINS OF THE CORRIGAN-MCKINNEY COMPANY, CLEVELAND.

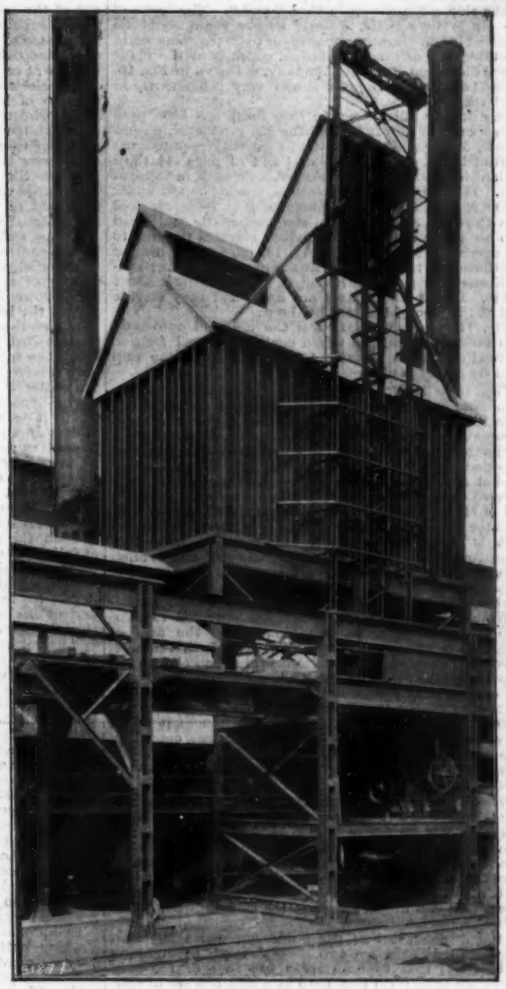


FIG. 14. THE FIRST FULL AUTOMATIC SKIP HOIST.

hopper emptied itself in the pit. This cannot occur with the device as shown in the illustration.

In some cases it is desirable to hoist more than one kind of material at different times with the same skip hoist. When materials with widely varying specific gravities, such as coke and ore, are to be hoisted, it is either a case of a full bucket of coke and a very small amount of ore, or it is necessary to shift the heavy counterweight. To overcome this difficulty a lever is employed with an adjustable lever arm. This adjustment can be made easily and quickly by the employment of a hand wheel mounted on a screw provided with a nut on to which is fastened the connecting rod.

Figs. 6 and 7, Plate XLI, exemplify a modern plant for the crushing and classifying of blast-furnace slag in which an automatic skip hoist receives crushed slag directly from a crusher and elevates it about 70 ft. to a revolving screen. Slag is a very abrasive material, but can be handled with a minimum amount of wear to equipment by means of a skip hoist. The shallowness of the skip pit is shown in Figs. 8 and 9. The depth of the pit is very little, if any, deeper than would be required for an elevator or conveyor to do the same work. A photograph of this installation, which is at the plant of the Cleveland Furnace Company, is shown in Fig. 10. A blast-furnace skip hoist shows very prominently in the background.

The double full automatic skip hoist has been used extensively for elevating coal for gas producers, power-houses, &c., where there is a large capacity required and a lift of 100 ft. or more. Figs. 11 and 12, page 434, show a plant in which run-of-mine coal is received in railroad cars. It is then dropped into a track hopper, under which is placed a feeding conveyor that feeds the coal to a two-roll crusher. From the crusher the coal is fed into an automatic skip hoist, which elevates the coal to the overhead storage bins. Fig. 13, page 435, shows an installation of this character at the plant of the Corrigan-McKinney Company, Cleveland, in which the lift is about 100 ft. Two 3-ton buckets are used, and they elevate coal at the rate of 175 tons per hour.

Fig. 14, page 435, illustrates the first full automatic skip hoist ever built, in which coal is received from a railroad car on an elevated trestle and fed to the skip hoist by a double plunger feeder.

Figs. 15 to 22, Plate XLII, illustrate a double, entirely automatic skip hoist that is handling hot nodulised ore from kilns to storage bins, operating under the most adverse conditions conceivable. Red-hot nodulised ore is discharged from two revolving kilns into a storage hopper provided with two gates in the bottom. When drawing red-hot material from the hopper a stream of water is sprayed on it, which causes the pit under the hopper to be full of steam and hot water. Any type of conveyor or elevator was out of the question, therefore a skip hoist that is entirely automatic, requiring no inspection whatever, was installed in the pit. The material handled being of an extremely abrasive character, a gate of rugged design was adopted. It is entirely of cast-iron, with a double shell enclosing an air space to assist in cooling.

White iron removable linings are provided to take care of excessive wear. For controlling the flow of material a semicircular cut-off gate of cast-iron is provided, operated by a bell crank and connection to the skip-hoist bucket. The construction of this gate and the detailed construction of the mechanical part of the automatic mechanism in the pit of this skip hoist are shown in Figs. 18 to 21. In some instances it is an advantage to have levers, counterweights, &c., out of the skip pit. In this case it was a necessity, owing to the steaming condition of the pit. Fig. 22 shows a view looking up the runway of this skip hoist.

When used entirely automatically the skip buckets are seldom made of a less capacity than 2 tons each. They are rectangular in shape, of steel plates ¼ in. to ½ in., with flat bottoms to rest on a counterweighted lever. When handling abrasive materials a renewable lining of steel plates is usually added. Two axles are used, on which are mounted chilled cast-iron or steel rollers that run in the guides of the skip runway.

The dumping of the bucket is accomplished entirely by the arrangement of the guides on which the skip rollers run. There are two general types of dumping guides: (1) that type in which all four of the skip rollers are alike; (2) that type in which one set of skip rollers has a wider flange than the other set. The first type depends entirely on gravity and the arrangement of the guides to properly discharge the bucket. For the second type two sets of rails are provided at the top of the runway, one pair for the front wheels of the skip bucket and the other pair, of wider gauge, for engaging a special tread on the rear wheels.

Fig. 23, Plate XLIII, shows a typical hoisting engine, consisting of a heavy structural steel base on which is mounted a cast-iron drum connected through a train of spur gears to an electric motor. The electric motor so admirably adapts itself to this type of mechanism that a steam engine has never been used in connection with an entirely automatic skip hoist.

The rope speed is seldom over 200 ft. per minute, which means a slow-speed drum shaft, consequently several sets of gears to get the proper speed from a motor running on an average about 850 r.p.m. The frame for mounting these various gear reductions, motor, &c., has passed through the experimental stage and is now made entirely of structural steel shapes properly stiffened and riveted. With this type of frame there is not the possibility of cracking that there was in the older type of cast-iron frames. To reduce friction and consequent wear to a minimum, all gears are cut and run in cast-iron oiltight gear cases. A solenoid brake, usually placed on an extension to the motor-armature shaft, is used on all engines of this type. The motor is fastened to this shaft extension by means of a flanged coupling, thus permitting the motor to be dismounted and replaced without disturbing the brake or any gears.

The success of the automatic skip hoist depends entirely on the electrical control. The mechanical control is a device for filling the skip bucket and starting the motor only, the major part of the operations of the equipment being performed by the electrical control, viz., accelerating the motor, decelerating, pausing, reversing, &c. The automatic electrical control consists of a plain slate panel supported on a steel frame, usually placed near the hoisting engine (see Fig. 24). On this panel are mounted the solenoid-operated primary reversing switches, also the various solenoid-operated accelerating switches, with their current relays. In the case of alternating current it is interesting to note that the primary reversing switch opens but two of the three phases, this being all that is necessary to reverse the motor. The third phase remains permanently connected to the line.

The accelerating switches automatically cut resistance out of the rotor circuit under control of current relays. The solenoid switches are so designed as to cut one step of resistance out of three phases of the rotor circuit simultaneously, thereby maintaining a proper electrical balance at all times.

The electrical control performs its functions through the use of a specially designed limit switch, which is geared directly to the hoisting-engine drum shaft through a set of bevel gears. This limit switch consists of a cast-iron case in which is mounted a long screw. On this screw is a travelling nut which moves back and forth as the motor is reversed, operating at the predetermined points sets of contacts, eight in all, four at each end of the limit switch. Fig. 25, Plate XLIII, illustrates the switch.

At any time that the power is shut off the hoist, either by the control or by accident, a solenoid-operated brake is automatically applied. The brake is freed by the raising of a counterweight by an energised solenoid. When power is cut off from the solenoid the weight drops, setting the brake.

The semi-automatic control system or, as it is sometimes called, the push-button control system, operates much the same as the full automatic type. It is used only where intermittent service is required or where the material is of such size and nature as to require special consideration at the loading point, and also where it is not convenient to have a storage hopper such as is required by the full automatic type. In order to understand the action of the semi-automatic type, let us consider that ore is to be handled intermittently. Assume the empty skip bucket at the bottom of the skip runway. This is filled with ore from a small car or chute. The starting button is then pushed, whereupon the bucket starts upward slowly, and after a short period of time the motor is accelerated, the bucket travelling at full speed until it reaches the upper position, at which point the slow-down resistance is inserted and the bucket brought to a stop in the dumping position, where it remains for a period of several seconds to insure the perfect discharge of the material from the bucket. It is then by means of a time-relay switch in the control system returned to the bottom or initial position, where it comes to rest and must so remain until the operator repeats the cycle of operation by pushing the starting button. Or, as in the case when two buckets are used in counterbalance, the pushing of the button starts the same cycle described above, except that the cycle ends with the stopping of the bucket in the dumping position, there not being required any time-relay switch.

Blast-furnace skip hoists constitute a large percentage of installations of this type, i.e., push button. More than 100,000,000 tons of ore are hoisted into blast-furnaces annually; practically all of which is handled by semi-automatic skip hoists.

Probably the next largest class of semi-automatic skip hoists are those used for elevating ashes into a bin or car. The usual condition is that in which a load of ashes is collected and brought to the hoist in a small car holding one skip bucket load. The man who collects the ashes is a very low-priced man, and all he has to do is to dump his load of ashes into the skip hoist, press the starting button, and go on about his business. The hoist automatically elevates the bucket, dumps the ashes, and the empty bucket returns to the loading position.

Fig. 26 shows an ash hoist that elevates ashes from a row of gas producers and deposits them into a bin that is located directly over a railroad track. Another installation for removing the ashes from a battery of gas-producers in a steel works is shown in Fig. 27, Plate XLIII.

The Firing of Coal Stores.—The British Fire Prevention Committee, of 8, Waterloo-place, Pall Mall, S.W. 1, have issued a leaflet containing precautions to be observed by those who have stores or stacks of coal. Copies can be obtained by sending stamped directed wrapper.

"The Flying Book."—The 1917 edition of this book, by W. L. Wade, published at the price of 3s. 6d. net by Messrs. Longmans, Green and Co., 39, Paternoster-row, E.C., has now appeared. It opens with a series of articles on aeronautics, aero engines, airships, &c., and then gives information on the modern aeroplanes of all nations arranged alphabetically, similar information on aero engines, followed by data on aeronautical organisations, a directory of manufacturing firms, notices on prominent men in aviation, an honours list and a diary for 1916, and a glossary of aviation terms. The book is carefully got-up and profusely illustrated, and forms a most useful and interesting guide on aeronautical subjects.

SWEDISH INDUSTRIAL ENTERPRISE.

Expansions, combines and increase of capital are still going on within different branches of Swedish industries, and in many cases on a large scale. The Scania-Vabis Engineering Company is increasing its capital from 4,500,000 kronor to 7,500,000 kronor (18 kronor = 1*l.* at par). The Keoster Bruk, comprising the Langshyttan concern, with blast-furnaces, Bessemer and Martin works, ingot-rolling mill, steam hammer, foundry, &c., the Strömsund concern, with wire and other rolling mills, &c.; the Rällingsbergs and the Smältesmoss mines, besides shares in some other half-score of mines, some 50,000 acres of forest, saw mill, limestone deposits, &c., have been purchased by the Stockholm Kullager (Ball Bearings) Company, the price being stated between 12,000,000 kronor and 13,000,000 kronor; the purchasing company is consequently increasing its capital by 12,000,000 kronor, in two issues. The Stockholm Ball Bearings Company ha, in a way, followed the example set by the two older Swedish ball bearings companies, the Swedish and the Northern. A still larger move is being made by the Grängesberg Traffic Company, which is contracting a loan of 40,000,000 kronor with which to pay for 18 iron ore steamers, of an aggregate tonnage of 115,000 tons, for which orders have been placed with the Göta yard, on the west coast of Sweden. Several new industries are being taken up, either by old concerns or new companies; thus a crucible manufactory on a fairly large scale is being started at Eskilstuna. A typewriter manufactory is also about to be formed, some capitalists having purchased the Halda watch factory; the manufacture of watches, however, will be discontinued. The Helsingborg Copper Works, amongst other extensions, are about to go in for the manufacture of electrolytic copper on a large scale. Detailed plans have been prepared, and the work will be proceeded with as fast as the necessary raw materials can be obtained. Hitherto Sweden has imported a considerable quantity of copper wire for electric lines, &c., from America, but the stoppage of supplies from this quarter has made a home manufacture desirable. One of the most important new departures is the formation of a large chemical company, with plenty of capital and excellent men at its back, in addition to which a large number of chemical engineers have been connected with the undertaking, which will boast the largest laboratory in Sweden. The programme is very comprehensive, and based not only upon home consumption, but also, to some degree at least, upon export. So far the preliminary labours have principally been confined to dye-stuffs, of which Sweden formerly imported some 1,000 tons annually from Germany. Altogether the German dye industry will find a somewhat altered world after the war. Benzol is the principal raw material, but this, as well as most of the chemical substances required, can be produced within the country, as is also the case with most of the plant. The work is planned to commence early in 1918.

An Employer's Duty.—Regulations require employers of labour to make a return of all male employees from 16 years of age, on a form, D.R. 17, obtainable at any post office, to the Recruiting Officer of the district in which the men work. A duplicate form should be kept by the employer on the premises, and both should be revised monthly if the occasion arises. Failure to comply with this regulation entails heavy penalties under Defence of the Realm Regulations 41A.

Cooling Shell Forgings by Compressed Air.—In a paragraph bearing this title which appeared on page 414 of our last issue we gave particulars of a process of cooling steel shell forgings which is in use at the works of the Canada Cement Company, of Montreal, and which, it was stated, had been devised by Mr. J. W. Dunphy. This, however, was an error. Our contemporary, *The Iron Age*, of New York, from which we quoted particulars, recently published an account of the process based on information supplied by Mr. Dunphy, but the process itself is that patented by Messrs. C. P. Sandberg and offered by them for use on munitions. The process has, we are informed, been widely adopted under instructions from the Ministry of Munitions in this country and also in Canada and the United States, and has been the means of reclaiming many thousands of shell forgings which had been rejected on physical tests.

Appeal to Motor Lorry Owners.—Founded in February, 1916, by Sir John Lister Kaye and Commandant C. R. Freemantle, the Motor Transport Volunteers have conveyed and assisted nearly 500,000 troops passing through London on leave. Without this splendid voluntary help, carried out every night of the year after the tube railways are closed, this vast force of men would have had to trudge through the dark, damp streets of London from the northern to the southern stations *en route* for the battle front. In addition to saving the men a most trying walk, the corps has speedily landed them, happy and contented, at a free buffet or at a soldiers' home, so that they continue their journey rested and refreshed. The Army Authorities supply the petrol, and all the officers and drivers of the corps give their services. There are at present in use 159 motor lorries, 186 private cars and 27 motor cycles with side-cars. Each vehicle covers an average of 60 miles a night. Motor lorries are loaned by 70 commercial firms in the London area, and Acting-Adjutant the Earl of Cottenham, 31, Walbrook, E.C.4, appeals to the heads of firms generously to lend their lorries for this most essential night work.

THE NATIONAL ASSOCIATION OF ENGINEERING FOREMEN AND SHOP MANAGERS.

To the Editor of Engineering.

Sir,—I have brought your excellent article on the subject of "The Hard Case of Engineering Foremen and Shop Managers" before the notice of all members of our local association, and they are in full agreement with its terms.

They realise that foremen cannot be dealt with on the same lines as the men at the bench, *i.e.*, their wages cannot be rigidly fixed by a society or union. In a large measure the value of a shop manager or foreman to any engineering firm must be determined by the particular firm employing him. He should, therefore, be quite as free an agent as his managing director. The regrettable part of the situation from 1916 to the present time has been that the foremen should have been made subject to the disabilities of a workman in the 1916 Munitions Amendment Act. The natural result of this has been the creation of a feeling of suspicion and distrust in the minds of the majority of foremen, managers and leading draughtsmen, seeing that the masters have not increased the wages of the foremen (except in a few cases) in proportion to the awards granted to the men.

Draughtsmen have been placed in the same boat, and while united action has done the rank and file some good, many leading or designing draughtsmen were, up to October 15, working on scales of pay agreed to before the war, and at the same time were unable to leave. With regard to most of the foremen members of this association, some four weeks ago the management dealt with their case in a reasonable manner.

I hope that the "National Association of Engineering Foremen and Shop Managers," which has now a concrete being, will prevent what has happened in the past occurring again. Reconstruction after the war will certainly not be assisted by a disagreement between foremen and their employers.

It is desired by my committee here to invite shop managers and foremen in engineering and allied trades in Reading, Basingstoke, Guildford, Woking and possibly Weybridge, to get into touch with the undersigned. Again thanking you for your valuable help in setting the case of engineering foremen so prominently before employers.

I am, yours faithfully,

Henry Greenly
(Hon. Secretary, Royal Aircraft Factory Foremen's Association).

Ashley-road, Farnborough, Hants, October 27, 1917.

DRAUGHTSMEN AND FOREMEN.

To the Editor of Engineering.

Sir,—I see that the abolition of the "leaving certificate" has at last come to pass, and also that the skilled mechanics on time rates are to receive an additional 12½ per cent. on their wages, making in all about 60 per cent. increase since August, 1914. In addition to these financial grants I note that honours and medals have been freely distributed among the munition workers; in fact a gracious Ministry of Munitions has showered blessings on the skilled, semi-skilled and unskilled munition worker without stint.

Alas! I have looked in vain for some tangible recognition, on the part of the Ministry, of the services given by the draughtsmen.

No doubt this oversight is largely due to the fact that the draughtsman's work is "not on view" to the newspaper man when he goes his rounds seeking copy, or to the Ministry officials when they go their rounds trying to appease the manual worker. The draughtsman works under a veil of secrecy, and woe unto you who try to enter the sacred portals of the drawing office. But surely the time has arrived when someone responsible should be brought to realise that there are others assisting the nation as well as the much-photographed munition worker.

Draughtsmen do not wish to deny the manual workers any of the good luck and honours they can get, but they justly feel that the veil of secrecy should be raised, so that the country can know that the brains of the engineering profession are "sticking it" asw ell as the "muscle," and, unfortunately for the "brains," at a reduced financial return.

I believe war bonuses from 5*s.* to 15*s.* per week are now paid by the majority of firms to their draughtsmen, but this is usually paid at the expense of the draughtsman not receiving his usual pre-war annual increase for increased efficiency and ability; thus the average draughtsman is probably worse off financially than he would have been under pre-war conditions, especially in view of increased national taxation.

Of course the draughtsman has not had the backing of a strong trade union, as the manual workers have, hence probably the apathy of the Ministry regarding his position; but possibly when the Association of Engineering and Shipbuilding Draughtsmen is compietely organised on a national basis, the Ministry will show themselves anxious and eager to offer gold and honours at the "shrine of the draughtsman."

Let it not be forgotten that the mechanical devices and machinery now in operation in the various war zones, as well as at home, are the outcome of the care and attention in design of the draughtsman, and it is not exaggeration to say that our military superiority over our enemies to-day is largely due to the work of the drawing-office staff.

Perhaps "some day" the Ministry will consider the draughtsman's care and award him some compensation in accordance with his undoubted value to the nation. In the meantime the draughtsman's alternative is to make his association a powerful one, so that the day may shortly dawn when he can be sure of a little sympathy and assistance from a Ministry that apparently only moves when the driving force is sufficiently powerful to become a danger to the State.

Yours faithfully,

October 18, 1917. A Draughtsman.

To the Editor of Engineering.

Sir,—The letter by "Draughtsman" in your issue of October 19 puts the whole case in a nutshell so far as the position of the ordinary draughtsman is concerned. He has always been treated in door-mat fashion, and I recollect the time when draughtsmen were working for 25*s.* a week while the ordinary engineer in the workshop received 38*s.* a week. To-day the average engineer is receiving from 3*l.* 15*s.* a week to 4*l.* per week, yet in the city of Glasgow there are draughtsmen earning from 25*s.* to 3*l.* 15*s.* a week, first-class men who spend nearly all their spare time studying to keep themselves in touch with the demands made upon them. A few days ago there was an advertisement in a well-known paper for junior and senior draughtsmen, at wages for juniors 30*s.* to 40*s.* a week, seniors 55*s.* a week. Now I ask your readers is it better to burn the midnight oil to earn 55*s.* a week, or to go into the shop and earn 3*l.* 15*s.* a week? However, the draughtsman has several points to consider, such as boys leaving school who come into offices and in a short time are able to make fairly good drawings and, when carefully supervised, do a lot of work. These boys generally work for little or nothing and practical experience counts for very little. Again, their parents are generally middle-class people and can afford to let them work for nothing for a long time. This is a form of sweated labour. If a draughtsman is considered to be an all-round man without being a specialist I think he ought at least to be better treated than he is. So far as foremen are concerned I think that they have nothing to do with the D.O. If the work of the draughtsman has been well considered and his drawings got up in proper readable fashion, then the foremen in the various shops have only to see that the work is carried out to the letter of the drawings and D.O. instructions. I would like if some of your D.O. correspondents would deal with the low-paid junior side of the D.O., for I have yet to learn of an invasion of the D.O. by the men from the shops.

These are the honest opinions of a practical engineer who has thought often on the submission that pervades the atmosphere of the ordinary D.O. As for the struggle that will take place after the war, let us hope that mankind will put a stop to senseless competition at home or abroad, and if one can earn a good living in the workshop and leave his work behind when his day's work is finished, it is preferable to carrying one's work in his head and receive nothing for it.

Yours truly,

John Stewart.

401, St. Vincent-street, Glasgow.

To the Editor of Engineering.

Sir,—The letters appearing in your issue of last week must have been read with keen satisfaction by the majority of draughtsmen. They can only be interpreted as the ebullition of long-felt irritation, and the growth of dissatisfaction which before long must find some other relief than in the mere scribbling of words. The average draughtsman has long since discarded the fetishes which so warped his conception of his industrial status and precluded a due appreciation of the communism of interest in his profession. In pre-war days he held himself aloof, nursed his ambitions, and dreamed of promotion; to-day the stern realities have banished his dreams and poignantly brought before him the menace of the industrial turmoil and the folly of his previous apathy in the kindred interests of his confrères. The practical issues which confront him daily have wrought a change, and his former supine indifference to the economic trend of industrial activities has been choked in the virile growth of those potential factors which lead to a strong vitalised organisation. He has been quick to grasp the fundamentals of combination, and the creative instinct, which is daily exercised in his vocation, has enabled him to grasp with avidity the practical effectiveness of a unification of purpose.

Hitherto reluctant to enter the arena of strife, he is surely being forced to adopt a more aggressive attitude, and this spirit has been engendered by the disparity of treatment which he receives, and is fostered by the complacent neglect of officials to recognise his prime importance in all ramifications of the engineering trades. His only solatium is the occasional overture of some academic writer who seeks to soothe his ruffled feelings with trite platitudes, or strives to belaud his virtues and indispensability in post-bellum industrial activities.

Draughtsmen are now looking for something more tangible and immediate. The restraints of the leaving certificate imposed immediate disabilities which reduced his status, and his relegation to the discretion of the employer for recognition of his skill, or for appreciation of his economic liabilities, was a departmental blunder, and one which we now seek the Ministry of Munitions to remedy. While some employers acted on their own initiative and sought to interpret the moral obligations imposed by the Munitions of War Act, others ignored their responsibilities, and the result is seen in the many anomalies of the wage-earning capacities of draughtsmen.

Lately we had a committee investigating the wages of skilled time-workers, and this has resulted in an advance of 12½ per cent. to engineers and ironmoulders. An effort has been made to level up the wages of the skilled mechanic, and the disparity of treatment is obvious when we consider the wages of the highly-skilled engineers who are working for time rates in the drawing office. The fitter is now earning a higher wage than the average draughtsman, and if the latter seeks to maintain his pre-war social status he is placed in a capricious position, fraught with anxiety and ominous for his future.

The whole situation is such a vexed one that we are urging the Ministry of Munitions to consider a basis of awards which would provide a more equitable arrangement than exists at present, and, with this aim in view, we have drafted and submitted to the Ministry a proposed basis which should tend towards an early settlement, and so remove much of the existing dissatisfaction.

Up till now the draughtsman has been the Cinderella of the engineering trades, a fit subject for all restraints and abuses and for the neglect of Government departments. In these prosaic days we can look for no resurrection of our fairy godmother; we can only place our reliance in a stronger and more determined attitude to secure a just and fairer recognition of our work among the engineering trades.

Now, sir, the facts and figures which we have at headquarters relative to the wages paid to draughtsmen, and to the conditions of their employment, are sufficient warrant for vigorous action to restore our status. Hitherto the essential spadework in building up an association of such rapid growth, and of co-ordinating the work in all our branches, has absorbed much energy and tended to diffuse our efforts, rather than concentrate our activities to well-defined channels. This phase is being rapidly passed, and draughtsmen now view with clearer perspective the issues that confront them, and, having eliminated much that was a source of weakness, are now eagerly preparing to tackle the existing problems.

The development of the draughtsman as a champion of his own cause is assured, and in post-war reconstruction he is a factor to be reckoned with. The task which lies before us is one which we ourselves fully appreciate, and our mistakes of the past are monuments to remind us of the sacrifices that have been made by our previous lack of means of concerted action, and the inability to have representation in all conferences where the interests of draughtsmen were concerned. In all Industrial Councils draughtsmen must have representation, otherwise their welfare is likely to be jeopardised in the conflict of opinions and in the clashing of interests. If the nation is to be thoroughly organised for the industrial and international competition that will follow in the wake of the war, the technicist must again take a foremost place, but he must be prepared effectively to voice his requirements and assist in the general reconstruction.

The dignity of his profession is in his own personal keeping; it depends on his conserving his ranks to the skilled, to the maintenance of the supply of fully-qualified draughtsmen, and to his resolution to withstand all encroachments that would impugn the general welfare.

In the Association of Engineering and Shipbuilding Draughtsmen he has established a strong and vigilant organisation, and it is with enthusiasm and a deeper understanding that he approaches the problems of the morrow.

I am, sir, yours faithfully,

William Herd
(President of the Executive Committee and Hon. Secretary of the Glasgow Council of the Association of Engineering and Shipbuilding Draughtsmen).

271, Crow-road, Partick, Glasgow, October 22, 1917.

GOVERNMENT EMPLOYMENT.

To the Editor of Engineering.

Sir,—It may interest you to know that since my letter of July 6 last, on "Government Employment," was published by you, there have been some changes at the Air Board. In what degree, if at all, my effort contributed to this I am unable to say, but I have, within the last week, learned that two technical civilian appointments have been made, one at 800*l.* and the other at 450*l.* per annum.

The best money paid to any technical civilian at the time of my own application was 4*l.* 4*s.* per week. I asked 6*l.* 6*s.* and was offered 5*l.*, which I declined.

Yours faithfully,

W. H. Thorpe.

60, Winsham-grove, Clapham Common, S.W. 11,
October 15, 1917.

Higher Coal Prices in Germany.—A meeting of the mine owners of the Rhenish-Westphalian Coal Syndicate has decided to raise the prices for the last quarter of the current year: For coal, 2.40 marks per ton; for coke, 3.60 marks per ton; for briquettes, 2.50 marks per ton inclusive of coal tax, so that the actual rise in prices for the materials is 2 marks, 3 marks and 2.8 marks to 2.10 marks per ton respectively. The Upper Silesian Coal convention has raised the price for coal 2 marks per ton, from October 1st, exclusive of the coal tax, so the increase in price is the same as for the large coal syndicate. There seems to have been some little doubt as to the coal tax also having to be levied upon any increase in prices (it came into operation August 1), and it is expected to yield material surplus above the calculated sum. The present increase in prices amounts to the same as the one adopted in May this year for coal and coke, whilst in May the rise for briquettes was 2.50 marks per ton, there being no tax then. Since the war commenced the aggregate increase in coal and coke and briquette prices amounts to 9 marks per ton for coal, 11 marks per ton for coke, 10.35 marks per ton for briquettes, without tax, for the Rhineland-Westphalia district, whilst the Upper Silesian coal prices only have risen 8 marks per ton since the commencement of the war.

THE QUEBEC BRIDGE.

As stated briefly in our issue of last week (*vide* page 404), on September 20 the last operation was successfully completed in the erection of the 1,800-ft. double-track span across the St. Lawrence River at Quebec. The bridge is notable not only for its unprecedented span and many special features of design and construction, but also for its eventful history and the determination that has completed the work in spite of unusual difficulties and misfortunes. After the substructure had been completed, the superstructure wholly fabricated and about half erected, one anchor arm, one cantilever arm, and nearly half of the centre connecting span suddenly collapsed, instantly killing most of the workmen, in August, 1907. Notwithstanding the heavy loss of life and property, work was soon resumed and an entirely new design was made for a bridge of the same span at the same site, and new engineers and contractors built a great fabricating shop, constructed new foundations, and had safely erected the huge anchor and cantilever arms comprising substantially the whole bridge except the centre span, when, on September 11, 1916, the assembled centre span, while being hoisted to position, fell and killed a number of workmen.

Undaunted by the great financial loss and the almost unbelievable failure of their careful and ably executed plans, the contractors cheerfully assumed full responsibility and immediately commenced reconstruction of the wrecked span, the failure fortunately having involved no other part of the structure. The previous design and methods were adopted without change except in a few minor details of the erection plant and in the modification of the temporary bearings, the failure of which was responsible for the fall of the span in 1916. The final erection was accomplished exactly according to programme without delay or difficulty of any kind, and the bridge now stands a completed triumph of engineering skill and marks a great advance in structural work.

The appreciation and admiration of engineers and contractors throughout the world is due to the men whose conspicuous abilities, courage, and devotion have accomplished this monumental work. The bridge was designed and constructed for the Dominion Government under the direction of the Quebec Bridge Commission, consisting of C. N. Monsarrat, chairman and chief engineer; Ralph Modjeski and H. P. Borden. The St. Lawrence Bridge Company, Limited, are the contractors, Phelps Johnson, being the president; G. H. Duggan, chief engineer; George F. Porter, engineer of construction; W. P. Ladd, superintendent of manufacture; S. P. Mitchell, consulting engineer of erection; and W. B. Fortune, superintendent of erection.

We gave on page 405 of our last issue a reproduction of a photograph showing the centre span during the process of lifting, and this view we supplement by another view on the opposite page, together with a diagram of the lifting tackle (Fig. 1), which will explain the arrangements clearly.

The erection of the 640-ft. centre span weighing about 5,400 tons was entirely independent of the cantilever construction, and was accomplished in three separate operations, namely, the assembling of the trusses on shore falsework; floating them to the bridge site; and raising them to the required elevation and permanently connecting them to the cantilever arms. The erection, towing, and hoisting operations were nearly identical with those which had been carried almost to completion a year ago, when the centre span was lost.* They differed in the character of the bearings at the ends of the lower chords on the lower lifting girders, which, in the previous operation, consisted of double cast-steel pedestals connected with longitudinal and transverse rocker pins, making a universal joint providing for displacement in both directions. The failure of one of these bearing castings caused the fall of the span. This type of bearing was therefore eliminated and was replaced by bearings consisting of solid forged steel and bronze plates confined between fixed guides, reducing the vertical distance between the lower lifting girder and the bottom of the span to a minimum distance.

The trusses, like those of the previously wrecked span, were erected on steel falsework in shallow water about 3½ miles from the bridge site. The panel points were supported on sand jacks. When complete the sand was run out of these jacks and the whole weight transferred to four girders resting on the end bents of the falsework. These girders were provided with eyes for the attachment of the chains used in the lifting of the span into place. The weight of the span was transferred to these girders, through expansion bearings, one under each outer rib of the chord member, as is indicated at R R in Fig. 2, which we reproduce from *The Railway Age Gazette*. The upper plate of the bearing was a steel bar, 3⅜ in. thick, riveted to the under surface of the span, and planed on its lower face and edges. The lower portion consisted of a steel trough riveted to the lifting girder, and filled first with a sheet of lead, then with two loose ¾-in. steel plates, and, finally, by a loose bronze plate, ¾ in. thick, planed and well greased. Expansion was provided for by the sliding of the upper steel plates over the bronze plates, whilst the compression of the lead allowed for the change in the camber of the truss as the sand was run out of the sand boxes and the weight of the span transferred to the end bearings. During the actual lift the weight was taken on a third bearing Q, Fig. 2. The upper bearing plate was in this case of nickel steel, measuring 4 ft. 6⅜ in. long by 12½ in. wide by 2 5/16 in. thick, whilst the lower shoe was of carbon steel, 3 7/16 in. thick. A nickel-steel bearing key, with an upper surface rounded to a radius of 24 in., transferred the weight from the upper shoe to the lower. This key was not put into place until the actual lift was about to commence. During the floating of the span

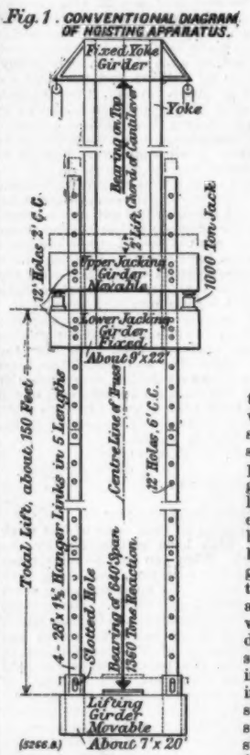
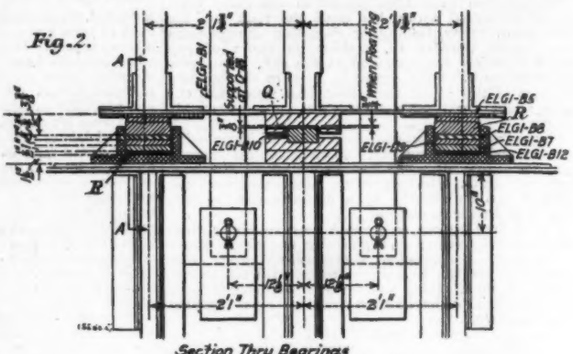


Fig. 1. CONVENTIONAL DIAGRAM OF HOISTING APPARATUS.
Fixed Yoke Girder
Yoke
Bearing on Top Chord of Cantilever
1000 Ton Jack
Upper Jacking Girder Movable
Lower Jacking Girder Fixed.
About 9'x22'
Total Lift, about 150 Feet
4 - 28"x 1⅛" Hanger Links in. 5 Lengths
Slotted Hole
Bearing of 640' Span 1560 Tons Reaction.
Centre Line of Truss
12" Holes, 6' C.C.
12" Holes 2' C.C.
Lifting Girder Movable
About 7'x 20'
(5256 a)



to the site its weight was carried entirely by scows supporting the span at intermediate points. The lifting girders then hung freely from the projecting ends of the truss. The boltholes in the links by which these lifting girders were slung from the span were oval, and thus sufficient play was provided for the dismantling of the shoes R R and the insertion of the bearing key in the central shoe Q. Six large scows stiffened with steel trusses were used for floating off the span. When conditions were favourable, early in the morning, September 17, water ballast was removed, and the scows floated, carrying the finished span with the lifting girders suspended from its ends. The span was towed to the bridge site, moored to special vertical trusses, suspended from the ends of the cantilever arms, adjusted to exact horizontal position, and thoroughly braced against transverse wind and tidal stresses. The lifting girders, one at each corner of the span, were then connected by pins through long slotted holes to temporary steel hangers suspended from the ends of the cantilever arms about 150 ft. above. At each corner there were two sets of hangers, each consisting of several lengths of vertical steel plates, pin-connected together and perforated with holes 6 ft. apart to receive the 12-in. carrying pins. The upper ends of the hangers passed through the lower jacking girder, suspended from the cantilever arm, and were at first pin-connected to the extremities of the upper jacking girder, movable just above the fixed lower jacking girder and in its place. Two 1,000-ton hydraulic jacks were inserted between the upper and lower jacking girders of each set and were operated simultaneously on all four corners of the bridge to lift the upper jacking girders 2 ft. at each operation. When that had been accomplished the hangers were pin-connected to the lower jacking girders and the upper jacking girders, being released, were lowered to their original positions, again pin-connected to the hangers, the hangers disconnected from the lower girders, and the jacking repeated, gradually lifting the span to the required position, where it was permanently pin-connected to the cantilevers and the jacking girders and hangers removed.

The span was hoisted 150 ft. in seventy-five 2-ft. lifts, each lift requiring from 13 minutes to 19 minutes, about half the time being occupied by the actual movement of the jacks, which were driven by a compressed air engine. The work was not carried on at night, and interruptions were necessary for removing the successive lengths of hangers as they were disengaged and for connecting and disconnecting the wind bracing which was during the erection subjected to the pressure from a 30-mile wind that displaced the span as much as 7 in. transversely and produced slight oscillation. After being hoisted to position the span was permanently connected to the cantilever arm by eight large pins driven through the groups of vertical eyebars.

The first Quebec Bridge was described in a series of articles published in Engineering in 1907. Some features of the progress of work on the present structure have since been published in successive articles on the substructure and on the fall of the centre span, and these notices will be supplemented by a complete description of the principal remaining features of design, and the fabrication and erection of the whole structure.

* See Engineering, vol. cii, pages 239, 304, 336, 364, 441 and 463.

Refractory Materials.—On the occasion of the recent Glasgow meeting of the Refractory Materials Section of the Ceramic Society the council appointed two sub-committees (with power to co-opt additional members) to prepare reports respectively on: (1) Standardisation of Methods of Testing; (2) Refractories for Spelter Furnaces. It is anticipated that the former will be ready for the spring meeting in Sheffield, and the latter for the subsequent autumn meeting at Cardiff.

British Petroleum.—Sir Boverton Redwood, Bart., Director of Petroleum Research, who has been adviser on petroleum to the various departments of the Government for many years, has been appointed, by Mr. Walter Long, Director of Technical Investigations in the recently created Petroleum Executive, with a view to his dealing with technical questions of the highest importance, including the co-ordination of the work of petroleum production and that of petroleum research. In order to devote himself to his new duties Sir Boverton Redwood will cease to act as Director of Petroleum Research.

Scientific and Technical Libraries.—In a report presented at the recent annual meeting of the Library Association stress is laid upon the desirability of establishing a State-aided library empowered to purchase and lend to approved applicants scientific and technical books. It is further urged: (*a*) that local authorities should afford more generous support to public libraries for the provision of scientific and technical literature; (*b*) that municipal and other library authorities and institutions should co-operate in issuing union catalogues of technical books, and adopt such other co-operative methods as will make their resources available over wider areas; (*c*) that a State scientific or technical library should publish periodically a descriptive list of selected books in science and technology; (*d*) that a more extended use should be made of periodical literature by the increased provision of current indexes and digests.

The Federation of British Industries.—The annual meeting of the Federation of British Industries was held in the Connaught Room on Friday last. Mr. F. Dudley Docker, C.B., in retiring from the chair, delivered an address in which he stated that much useful and painstaking "spade work" had been accomplished by the executive committee during the year. He expressed the view that power to bargain with foreign nations for reciprocal trade concessions should be secured, if necessary, by the imposition of duties. He stated, further, that he was authorised by the Prime Minister to say that the latter would welcome any federation of industry, which would, he considered, be of assistance to the Government. Mr. Docker said, further, that the object of the federation should be to obtain a similar recognition and status in the eye of the law as was now enjoyed by the trade unions. At the meeting Sir R. Vassar Smith was elected president for the ensuing year.

THE HOISTING OF THE CENTRAL SPAN OF THE QUEBEC BRIDGE.

(*For Description, see opposite Page.*)

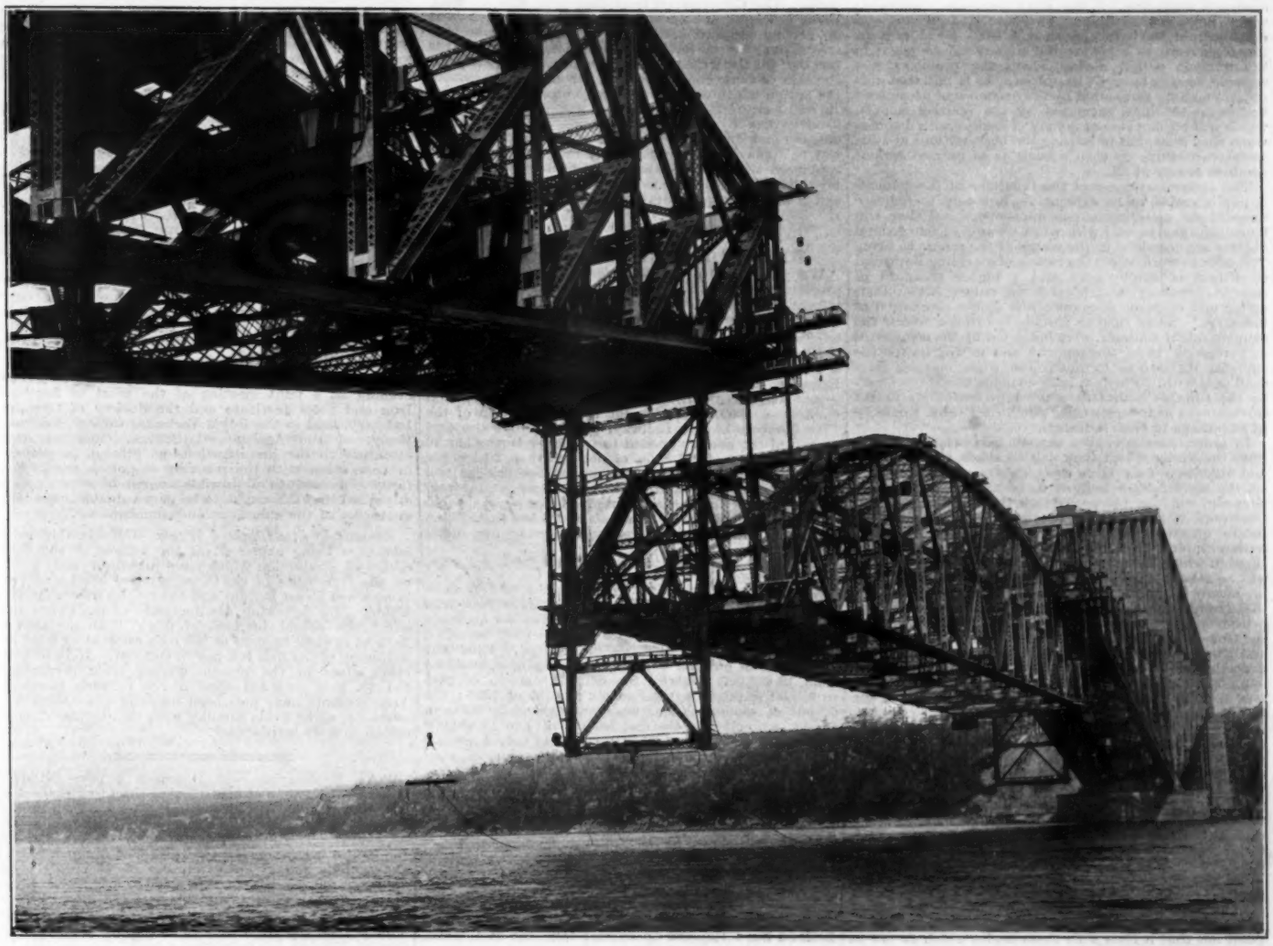


Fig. 3.

JOINT STANDING INDUSTRIAL COUNCILS.

The following communication has been sent by the Minister of Labour to a considerable number of associations of employers and employed, and deals with several questions raised in our leading article in last week's issue (page 417 *ante*):—

In July last a circular letter was addressed by the Ministry of Labour to all the principal employers' associations and trade unions asking for their views on the proposals made in the report of the Whitley Committee on Joint Standing Industrial Councils, a further copy of which is enclosed. As a result of the replies which have been received from a large number of employers' organisations and trade unions generally favouring the adoption of those proposals, the War Cabinet have decided to adopt the report as part of the policy which they hope to see carried into effect in the field of industrial reconstruction.

In order that the precise effect of this decision may not be misunderstood, I desire to draw attention to one or two points which have been raised in the communications made to the Ministry on the subject, and on which some misapprehension appears to exist in some quarters.

In the first place, fears have been expressed that the proposal to set up Industrial Councils indicates an intention to introduce an element of State interference which has hitherto not existed in industry. This is not the case. The formation and constitution of the councils must be principally the work of the industries themselves. Although, for reasons which will be explained later, the Government are very anxious that such councils should be established in all the well-organised industries with as little delay as possible, they fully realise that the success of the scheme must depend upon a general agreement among the various organisations within a given industry and a clearly expressed demand for the creation of a council. Moreover, when formed, the councils would be independent bodies electing their own officers and free to determine their own functions and procedure with reference to the peculiar needs of each trade. In fact, they would be autonomous bodies, and they would, in effect, make possible a larger degree of self-government in industry than exists to-day.

Secondly, the report has been interpreted as meaning that the general constitution which it suggests should be applied without modification to each industry. This is entirely contrary to the view of the Government on the matter. To anyone with a knowledge of the diverse kinds of machinery already in operation, and the varying geographical and industrial conditions which affect different industries, it will be obvious that no rigid scheme can be applied to all of them. Each industry must therefore adapt the proposals made in the report as may seem most suitable to its own needs. In some industries, for instance, it may be considered by both employers and employed that a system of Works Committees is unnecessary owing to the perfection of the arrangements already in operation for dealing with the difficulties arising in particular works between the management and the trade union officials. In others, Works Committees have done very valuable work where they have been introduced and their extension on agreed lines deserves every encouragement. Again, in industries which are largely based on district organisations it will probably be found desirable to assign more important functions to the District Councils than would be the case in trades which are more completely centralised in national bodies. All these questions will have to be threshed out by the industries themselves and settled in harmony with their particular needs.

Thirdly, it should be made clear that representation on the Industrial Councils is intended to be on the basis of existing organisations among employers and workmen concerned in each industry, although it will, of course, be open to the councils, when formed, to grant representation to any new bodies which may come into existence and which may be entitled to representation. The authority, and consequently the usefulness of the councils, will depend entirely on the extent to which they represent the different interests and enjoy the whole-hearted support of the existing organisations, and it is therefore desirable that representation should be determined on as broad a basis as possible.

Lastly, it has been suggested that the scheme is intended to promote compulsory arbitration. This is certainly not the case. Whatever agreements may be made for dealing with disputes must be left to the industry itself to frame, and their efficacy must depend upon the voluntary co-operation of the organisations concerned in carrying them out.

I should now like to explain some of the reasons which have made the Government anxious to see Industrial Councils established as soon as possible in the organised trades. The experience of the war has shown the need for frequent consultation between the Government and the chosen representatives of both employers and workmen on vital questions concerning those industries which have been most affected by war conditions. In some instances different Government Departments have approached different organisations in the same industry, and in many cases the absence of joint representative bodies which can speak for their industries as a whole and voice the joint opinion of employers and workmen, has been found to render negotiations much more difficult than they would otherwise have been. The case of the cotton trade, where the industry is being regulated during a very difficult time by a Joint Board of Control indicates how greatly the task of the State can be alleviated by a self-governing body capable of taking charge of the interests of the whole industry. The problems of the period of transition and reconstruction will not be less difficult than those which the war has created, and the Government accordingly feel that the task of rebuilding the social and economic fabric on a broader and surer foundation will be rendered much easier if in the organised trades there exist representative bodies to which the various questions of difficulty can be referred for consideration and advice as they arise. There are a number of such questions on which the Government will need the united and considered opinion of each large industry, such as the demobilisation of the forces, the re-settlement of munition

workers in civil industries, apprenticeship (especially where interrupted by war service), the training and employment of disabled soldiers, and the control of raw materials; and the more it is able to avail itself of such an opinion the more satisfactory and stable the solution of these questions is likely to be.

Further, it will be necessary in the national interest to ensure a settlement of the more permanent questions which have caused differences between employers and employed in the past, on such a basis as to prevent the occurrence of disputes and of serious stoppages in the difficult period during which the problems just referred to will have to be solved. It is felt that this object can only be secured by the existence of permanent bodies on the lines suggested by the Whitley Report, which will be capable not merely of dealing with disputes when they arise, but of settling the big questions at issue so far as possible on such a basis as to prevent serious conflicts arising at all.

The above statement of the functions of the councils is not intended to be exhaustive, but only to indicate some of the more immediate questions which they will be called upon to deal with when set up. Their general objects are described in the words of the report as being "to offer to workpeople the means of attaining improved conditions of employment and a higher standard of comfort generally, and involve the enlistment of their active and continuous co-operation in the promotion of industry." Some further specific questions, which the councils might consider, were indicated by the committee in paragraph 16 of the report,* and it will be for the councils themselves to determine what matters they shall deal with. Further, such councils would obviously be the suitable bodies to make representations to the Government as to legislation, which they think would be of advantage to their industry.

In order, therefore, that the councils may be able to fulfil the duties which they will be asked to undertake, and that they may have the requisite status for doing so, the Government desire it to be understood that the councils will be recognised as the official standing Consultative Committees to the Government on all future questions affecting the industries which they represent, and that they will be the normal channel through which the opinion and experience of an industry will be sought on all questions with which the industry is concerned. It will be seen, therefore, that it is intended that Industrial Councils should play a definite and permanent part in the economic life of the country, and the Government feels that it can rely on both employers and workmen to co-operate in order to make that part a worthy one.

I hope, therefore, that you will take this letter as a formal request to your organisation on the part of the Government to consider the question of carrying out the recommendations of the report so far as they are applicable to your industry. The Ministry of Labour will be willing to give every assistance in its power in the establishment of Industrial Councils, and will be glad to receive suggestions as to the way in which it can be given most effectively. In particular, it will be ready to assist in the convening of representative conferences to discuss the establishment of councils, to provide secretarial assistance and to be represented, if desired, in a consultative capacity at the preliminary meetings. The Ministry will be glad to be kept informed of any progress made in the direction of forming councils. Although the scheme is only intended, and indeed can only be applied, in trades which are well organised on both sides, I would point out that it rests with those trades which do not at present possess a sufficient organisation to bring it about if they desire to apply it to themselves.

In conclusion, I would again emphasise the pressing need for the representative organisations of employers and workpeople to come together in the organised trades and to prepare themselves for the problems of reconstruction by forming councils competent to deal with them. The Government trust that they will approach these problems not as two opposing forces each bent on getting as much and giving as little as can be contrived, but as forces having a common interest in working together for the welfare of their industry, not merely for the sake of those concerned in it, but also for the sake of the nation which depends so largely on its industries for its well-being. If the spirit which has enabled all classes to overcome by willing co-operation the innumerable dangers and difficulties which have beset us during the war is applied to the problems of reconstruction, I am convinced that they can be solved in a way which will lay the foundation of the future prosperity of the country and of those engaged in its great industries.

* Paragraph 16 of the report referred to above is as follows:—Among the questions with which it is suggested that the National Councils should deal or allocate to District Councils or Works Committees, the following may be selected for special mention:—

(i) The better utilisation of the practical knowledge and experience of the workpeople.

(ii) Means for securing to the workpeople a greater share in and responsibility for the determination and observance of the conditions under which their work is carried on.

(iii) The settlement of the general principles governing the conditions of employment, including the methods of fixing, paying, and readjusting wages, having regard to the need for securing to the workpeople a share in the increased prosperity of the industry.

(iv) The establishment of regular methods of negotiation for issues arising between employers and workpeople, with a view both to the prevention of differences, and to their better adjustment when they appear.

(v) Means of ensuring to the workpeople the greatest possible security of earnings and employment, without undue restriction upon change of occupation or employer.

(vi) Methods of fixing and adjusting earnings, piecework prices, &c., and of dealing with the many difficulties which arise with regard to the method and amount of payment apart from the fixing of general standard rates, which are already covered by paragraph (iii).

(vii) Technical education and training.

(viii) Industrial research and the full utilisation of its results.

(ix) The provision of facilities for the full consideration and utilisation of inventions and improvement designed by workpeople, and for the adequate safeguarding of the rights of the designers of such improvements.

(x) Improvements of processes, machinery and organisation and appropriate questions relating to management and the examination of industrial experiments, with special reference to co-operation in carrying new ideas into effect and full consideration of the workpeople's point of view in relation to them.

(xi) Proposed legislation affecting the industry.

FOREIGN ENGINEERING PROJECTS.

We give below a few data on a foreign engineering project, taken from *The Board of Trade Journal*. Further information can be obtained from the Department of Commercial Intelligence, Board of Trade, 73, Basinghall-street, London, E.C. 2.

Brazil.—The *Diario Official*, Rio de Janeiro, publishes a Decree (No. 12,581) granting to the Companhia de Estradas de Ferro Federaes Brasileiras (Sul-Mineira system) an extension, up to May 31, 1918, of the period fixed by a 1909 concession for the construction of the Tres Coraçoes-Lavras Railway, provided that the first 41 km. of the line are opened to traffic by November 30 next. The use of old rails, of not less than 20 kg. per metre and of wooden superstructures for bridges will be provisionally allowed, but within two years from the date fixed for the completion of the line the old rails must be replaced by new rails of not less than 25 kg. per metre, and any unsafe wooden bridges by new metal structures.

The Russian Iron Industry during the War.—In Russia, as in other belligerent countries, the iron industry has been so intensely employed for military purposes that the manufacture of what may be called peace products has been much reduced. Thus the production of girders, to mention an example, declined from 10,850,000 poods in the first six months of 1913 to 2,750,000 poods in the first six months of 1916; the output of roofing sheets, which are generally used in Russia, amounted in the first half of 1913 to 11,820,000 poods, and in the same period of 1916 to only 5,890,000 poods. On the other hand, the production of steel for shells rose from 1,960,000 poods during the first nine months of 1913 to 16,560,000 poods during the first nine months of 1916. The fact that any supplies from the Polish iron works were out of the question tended to increase the production in Southern Russia and the Ural district of such articles which had formerly been more or less of a Polish speciality. (1 pood = 36 lb.)

Electric Truck for Wharf Work at Wellington, New Zealand.—H.M. Trade Commissioner in New Zealand has forwarded an extract from the local press, which is to the effect that a series of tests have been carried out at Wellington with a new electric storage-battery truck, intended for use on the water-front. The truck is of American manufacture, and is the first of its kind in New Zealand. It is about 8 ft. long and 3 ft. wide, and runs on four small wheels placed underneath the body. The batteries, of which there are 42 of the Edison type, are carried under the platform, and thus do not take up any carrying space. The batteries are capable of running the truck for a full working day. The driver stands on two divided steps at the end of the vehicle. One of these steps switches the current on when it is desired to start the truck, and the other controls the brake. The steering, which is done on all four wheels, is effected by a tiller, and the electric motor is controlled by a small lever placed at one side of the platform. The capacity of the truck itself is 4,000 lb. The price of the truck is about 500*l.*, and it will possibly be purchased by the Wellington Harbour Board.

Shipbuilding in Germany.—The Blohm and Voss yard in Hamburg, which last October increased its capital with 8,000,000 marks, so that it now amounts to 20,000,000 marks, half ordinary and half preference shares, has for the last financial year earned 8,388,646 marks in working profits against 6,088,835 marks for the previous year. Social burdens, as the technical phrase is, absorbs 632,671 marks, war aid for officials and men 1,782,377 marks, or more than 700,000 marks in excess of last year's figures, the amount written off was 3,220,294 marks against 2,564,376 marks for the preceding year. The net profits amount to 2,376,983 marks against 1,530,960 marks for the previous year. The dividend was fixed at 6 per cent. for the ordinary and 5½ per cent. for the preference shares. The report states that on account of the war details cannot be gone into. The yard, plant, &c., stand on the books at 44,580,000 marks, 9,370,000 marks being attributed to the floating dock, 15,950,000 marks to buildings, cranes, &c., and 19,250,000 marks to machinery, &c. The Nüske shipyard in Stettin has increased its capital from 2,000,000 marks to 3,000,000 marks. The company has not done particularly well hitherto, but has improved its position during the war.

NOTES FROM THE NORTH.

Glasgow, Wednesday.

Scotch Steel Trade.—In the steel-making industry little change takes place from day to day—every possible mill is running on full time, and were labour more plentiful there would not be an idle mill in the whole district. Government restrictions are daily becoming more and more stringent. Steel plates and sections for shipbuilding purposes are still greatly in request, and recent improvements in their production have now made possible a more satisfactory system of delivery. An astonishing amount of work is now being put through with shell discard steel.

Malleable Iron Trade.—War work continues to absorb practically the entire attention of malleable iron makers in the West of Scotland—order books are full and the general activity is unceasing. The home demand is so excessive that shipments, meantime, are not nearly so heavy as they were, although the demand for marked bars for the export trade remains particularly steady in spite of the stringent restrictions of Government on both the iron and steel products. For shipment, 16*l.* per ton, f.o.b. Glasgow, is being readily given for marked bars.

Scotch Pig-Iron Trade.—The demand for pig-iron of all grades is increasingly active. Many of the furnaces have been turned over to the production of basic. So long as the national demand continues at its present level little or no export can possibly take place. Prices are alike firm and steady.

Potash from Blast-furnace Gases.—Speaking on Friday evening at a joint meeting of the West of Scotland Iron and Steel Institute and the Society of Chemical Industry, held in the Royal Technical College, Professor Berry, of the Agricultural College, Glasgow, drew attention to the investigations at present in progress in connection with the recovery of potash from blast-furnace gases. As a possible source of supply, it is estimated that this ought to be very valuable, especially in respect of the enormous output meantime.

Advance of Steel Makers' Wages.—Considerable satisfaction is being expressed at the awards of the Committee of Production which have just been made public by the secretaries of the Amalgamated Steel and Iron Workers of Great Britain and the British Steel Smelters' Union. The following are the terms of the award that affect the actual increase of pay: "An advance of 3*s.* a week shall be paid to the men affected as from the beginning of the first full pay in October. If an increase takes place in the present sliding scale percentages the 3*s.* now awarded shall merge in such increase." Arrangements have also been made in connection with overtime, night work, Sunday work and holidays, which are all entirely satisfactory.

Peat Briquettes.—In Denmark a peat briquette factory is in course of construction close to Brönderslev, where an attempt was made some years ago with English capital to start the manufacture of ammonia and briquettes. The peat briquette is of similar shape to the lignite briquette, but the substance is much harder, almost like glass. Their number of British thermal units is 8,100, against between 3,500 to 6,300 for ordinary peat. The briquettes are made from natural peat containing some 90 per cent. of water, of which the bulk is removed by a preliminary process, so that the peat is reduced by pressure to about one-quarter the original weight. The peat substance is then subjected to a similar process as that used in the lignite briquette manufacture, a pressure from 1,200 atmospheres to 1,500 atmospheres, the bituminous substances of the peat serving as cementing medium. The new factory will commence with 1,200 acres of bog, with the option of taking over the remaining portion of the English lease, which altogether in this district comprises 4,300 acres of the Store Vildmore deposits. There will be two compressors, each with engines of 210 h.p. The price had been fixed at 29*s.* per ton on the spot. It is anticipated that at this price the whole share capital of 45,000*l.* will be written off in the course of three years.

Ionisation of Potassium Vapour by Light.—The ionisation of potassium vapour by radiations has been supposed to require ultraviolet light. According to J. A. Gilbreath, of the University of Washington, ionisation takes place also by the action of ordinary light. Gilbreath (*Physical Review*, August, 1917) used a long horizontal vacuum bulb, the far end of which was prolonged into a tube which was bent downwards and contained a little metallic potassium in the small bulb at its extremity. The lamp, a 500-watt tungsten lamp (nitrogen-filled), was placed in front of the other end of the vacuum bulb in such a way that the rays of light could pass through the space between the two opposite disc electrodes of the bulb (which were charged to several hundred volts) without touching them, or could strike the positive or the negative electrode. The bulb being made of ordinary glass, the light entering the bulb was supposed to be ordinary light. The tension of the potassium vapours in the bulb was only 0.005 mm. of mercury; by heating the bulb at the far end the vapour tension was raised, and by heating it at the electrode end (so as to drive the vapour away from the electrodes) the tension could be reduced; by cooling the whole tube the vapour tension was also decreased. When the vapour tension was decreased, the photo-electric currents observed also decreased; the direction of the rays with regard to the electrode—striking one of them or not touching either, as explained—made little difference; the light thus seemed directly to ionise the vapour.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—All classes of fuel are being handled more and more on account of contracts and Government specifications, so that the opportunities for open market business are becoming even more remote than ever, and little, if any, trade now passes in this way. Pits are working at full pressure to maintain the ordinary requirements of consumers, and there is nothing left over for reserves at the collieries. The principal demand is for the best steam hards, the South Yorkshire steam sorts being in strong request all round. Local works are pressing for maximum deliveries, and the Admiralty and other war requirements take up the remainder of the output. Cobbles and steam nuts are in much the same position, whilst gas companies find it a matter of some difficulty to secure the full amount they are wanting for the winter season. A good tonnage passes for inland works, but the export figure is smaller than ever before. Slacks fluctuate considerably, the position in the Lancashire cotton trade having much to do with the changeable character of the market. Cokes are again unchanged, and top prices are paid for all deliveries. The household section has become tighter on the week, and dealers and merchants find their order books filling rapidly. Many arrears remain to be wiped off. The new list of quotations is as follows:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; best large nuts, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 9*d.* to 18*s.* 9*d.*; best slacks, 14*s.* 6*d.* to 15*s.*; seconds, 13*s.* to 13*s.* 6*d.*; and smalls, 9*s.* to 10*s.* per ton at the pit.

Iron and Steel.—Output is the first consideration of the moment, and some very satisfactory figures are now being attained in all departments. The production of acid steel is on a mammoth scale, and there is every prospect of this being advanced still further. Nevertheless these improved figures, and also the dwindling of the domestic trade, do not materially alter the situation, which remains tight in spite of them. One can thus gather in a general way the enormous extent of the demands for military purposes. Nor is this peculiar to the acid steel section. High-speed steel makers find that they have a market for their material almost before the melting is completed, whilst tool-makers have abundant orders on hand for Government work of every variety in their particular line. It may be noted here that good progress is being made with the workshop additions to many of the better-known tool shops in the city, and that these are of a solid, substantial character, which portend after-war trade development. Carbon tools are not in such large request, but the demand is nevertheless very insistent. Basic steel is coming to hand more freely. Government restrictions with regard to overseas trade, particularly in connection with Sweden, are leading to a general strengthening of the home raw material position in favour of the maker. Supplies of all descriptions are in demand. Forge and foundry iron are being bought as fast as the makers can produce, and there is no surplus. Works, therefore, cannot put much to stock. Basic iron is a better supply, but little business is being done in the Swedish sorts. Rates are inflated, and buying is done on a careful system. It is hoped that the movement to manufacture a substitute for Swedish iron in this country by means of electric furnaces will succeed, and ease the conditions. Heavy iron foundries have many orders for steel works' plant and machinery. The London County Council has again come to Sheffield, and this time has placed an order for 1,500 driving-wheel and 750 pony-wheel tyres at a cost of 7,294*l.* File makers are meeting a sudden rush for a particular file in a manner which promises success. Cutlers are still perturbed about the restrictions regarding stainless cutlery, which we have mentioned in these notes from time to time during the last few weeks, but not much hope is entertained that the Government will change its attitude whilst conditions remain as they are. The latest list of overseas orders includes substantial requirements of engineers' tools, machetes, springs, sheep shears, knives for butchers and farriers, saws, sickles, hardware and steel.

Sheffield Trade Matters.—Sheffield Chamber of Commerce held a special meeting this week, when there was some rather strong talk on the question of the interference by politicians in trade matters, and a desire was expressed that the restrictions would be removed at as early a date as possible after the war. Mr. Peter McGregor, the president, in mentioning that steps had been taken to secure Sheffield's trade position, said they did not want hampering. Mr. Arthur Balfour, a leading steel manufacturer, said if they liked to allow themselves to be controlled by a lot of politicians and office-seekers in London after the war they would be controlled, but if they refused, the thing would fall through. A resolution was passed urging the Government to remove all restrictions on trade at the earliest possible moment after the war, as the Chamber was convinced that the trade of the country would suffer very materially if the present conditions were maintained.

RÖNTGEN SOCIETY.—The opening meeting of the Röntgen Society will be held on Tuesday, November 6, at 8.15 p.m., at the Royal Society of Arts. The Presidential address, on "The Part Played by X-Rays in the War," will be delivered by Captain G. W. C. Kaye, M.A., D.Sc., and occasion will be made for an exhibit of apparatus, radiological and electro-therapeutic, illustrating the most recent developments in such appliances. Those interested are invited to attend.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The Cleveland iron market is very strong, and advances in quotations are anticipated, but business is quiet. Consumers of Cleveland foundry pig-iron are still obtaining supplementary allocations without difficulty, but there seems a possibility of all the iron bought for this month not being delivered, especially as shortage of trucks is still hampering distribution. October purchases have been exceptionally heavy. What balance is not dispatched will have to be made the subject of fresh allocation next month. Further substantial sales of forge iron are reported, most of the sales having been made at a trifle below the fixed maximum price. This quality is not subject to allocation, and contracts have been entered into for supply to the end of the year. Though sales have been made at below the maximum, many makers adhere firmly to that figure, and are not disposed to make contracts otherwise than subject to any official increase which may be decided upon. Export business is dull. There is considerable congestion of applications. For home consumption No. 3 Cleveland pig-iron, No. 4 foundry and No. 4 forge are all quoted 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*; and for shipment to the Allies No. 3 is 102*s.* 6*d.*, No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.* The stock of Cleveland pig-iron in the public warrant stores still stands at 887 tons, all of which is No. 3 quality, no change having been recorded since the 3rd inst., on which date 250 tons were withdrawn.

Hematite Iron.—Very little news is ascertainable concerning the East Coast hematite department. Though conditions are still stringent, the general position is regarded as better, and with preparations for the enlargement of output of steelmaking iron proceeding quite satisfactorily, further relief to the situation promises to be experienced at an early date. The intense demand absorbs the whole of the make as quickly as it is turned out. Home deliveries are carefully regulated, and are such as to meet all essential needs, but exports are permitted on only a strictly limited scale. Nos. 1, 2 and 3 are put at 122*s.* 6*d.* for home use and 141*s.* for shipment to France and to Italy.

Coke.—Coke is in very ample supply, but prices are very stiff, and are expected to follow the recent advance in coal. For blast-furnace descriptions local demand is heavy, and fixed maximum rates are readily realised, medium kinds being bought at 28*s.* at the ovens, and qualities low in phosphorus at 30*s.* 6*d.* at the ovens.

Foreign Ore.—A moderate business in foreign ore is being put through as occasion offers, and outside ores, which under normal conditions consumers are not disposed to look at, find a ready market. Most consumers, however, are very heavily bought, and are more concerned with deliveries than with new business. Needs of consumers are met by the careful distribution of the Control Committee.

Cleveland Miners' Wages.—The Cleveland ironstone mine-owners' and miners' representatives, at a meeting this week, arranged that the recent award of the Coal Controller should apply to the Cleveland ironstone miners and the Weardale quarrymen. The war wage grant to the miners and quarrymen under the Controller's award (1*s.* 6*d.* extra per shift for adults, and 9*d.* for boys) takes effect from September 17 last, and it was understood as regards the ironstone miners that the extra payment to the 27th inst. will be made to the men on the 3rd proximo, and with respect to the quarrymen, with whom fortnightly pays prevail, that the additional money will be paid on the 2nd or 9th proximo, as pay falls due.

Manufactured Iron and Steel.—The huge Government needs and the very heavy requirements of the shipyards continue to keep finished iron and steel manufacturers running at highest pressure, and practically the whole of the output is absorbed in these directions. Values, all round, are very stiff. To home customers the following are among the principal market quotations:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; best best best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 19*l.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 15*l.* 10*s.*; heavy sections of steel rails, 10*l.* 17*s.* 6*d.*; packing iron and steel (parallel), 13*l.* 10*s.*; and packing iron and steel (tapered), 15*l.* 15*s.*

THE NEW TROLLHÄTTA CANAL.—The largest vessel which so far has passed the new Trollhätta Canal is the Norwegian steamer Eikland, 2,500 tons deadweight, which has proceeded to Venern to take in cargo.

THE "ENGLISH GAS ANSTALT" IN GERMANY.—The disposal by the Government of the Englische Gasanstalt is giving rise to much criticism and will, it is predicted, be followed by fierce struggles in the future. The urban districts Teltour and Niederbarnim have offered the German Government the price asked, viz., 85,200,000 marks, whilst the city of Berlin and Greater Berlin communities have kept aloof from making an offer at this second time of asking, all complaints and charges put forward by Greater Berlin, either directly to the Government or through the press, having been entirely ignored. The urban districts in question seem to have arrived at a secret understanding with the Government, which is expected to offer the purchasers material financial facilities.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Market.—Chief interest on the Cardiff market this week has centered in the special meeting of the Chamber of Commerce which had been convened to consider current reports of offers by certain firms to supply France with large quantities of coal, and to decide what action, if any, shall be taken. At the present moment exports to France are being regulated by the limitation scheme, and a vital principle of that scheme is that exports to France should continue as far as practicable through the usual channels. The recent rumours were construed as implying a total disregard of this principle, and it was for this reason that they were regarded with so much apprehension in the South Wales coal trade circles. The meeting to-day threw some light on the nature of the offers which have been made, and dispelled the worst fears of exporters, but it left one or two aspects of the question unsettled, and it is difficult to anticipate what course events will take when the present restrictions are removed and business is again left to the comparatively unfettered sway of competition. Business has been very quiet, but there has been a fair amount of tonnage in dock, and shipments, on the whole, have been satisfactory.

Newport.—Quiet conditions have again prevailed on the market for Newport coals. The volume of shipments has been well up to recent averages, and with tonnage moving more freely than was the case a week or two ago, arrivals are improving both in quantity and in regularity. This improvement has reacted on the position in the Western and Eastern Valleys, and there was a reduction in the number of pits idle; otherwise the market has been featureless.

Coal Trimmers and Pooling of Labour.—The coal trimmers in the South Wales ports have formulated a scheme for the pooling of labour. The underlying idea is an attempt to provide a more equitable distribution of labour. While trimmers in the employ of large firms are provided with practically regular work, the same does not apply, particularly in these days, to the class of workmen known as hobblers, and hence the disaffection. The new scheme involves at least one important principle, and that is that the men individually will not be engaged permanently by the respective firms. The effect of the adoption of the scheme would be that the allocation of work would rest with the Coal Trimmers' Union, who would detail the men by rota when their services would be required by the different firms. In this way, it is held, there would be obviated the possibility of some men being continuously employed while others were idle for varying periods. It has been decided that a ballot of the members of the Coal Trimmers' Union be taken on the issue of the adoption of the scheme.

Coal Controller's New Directions.—It was announced by Mr. T. J. Callaghan, at the meeting of the Cardiff Chamber of Commerce held to-day, that the Coal Controller had laid it down that the 2*s.* 6*d.* per ton extra stipulated in the Coal Controller's new instructions, was to apply to all coals supplied to British Possessions and coaling stations, and that only coals supplied to France and Italy were exempt from the impost.

TRAFFIC ON THE SWEDISH RAILWAYS.—The company-owned Swedish railways show a considerable increase in receipts for the first six months of the present year as compared with the same period last year, the aggregate amounts being respectively 66,413,000 kronor and 57,372,000 kronor. This is equivalent to an increase of 15.8 per cent., 18.4 per cent. on the goods and 9.5 per cent. on the passenger traffic. The increase in the goods traffic receipts is exclusively due to the higher tariff, temporarily adopted. The private railways are contemplating a material reduction in the number of trains during the winter, whilst the State railways mean to meet the shortage of fuel problem by reducing the speed.

LOCOMOTIVE DEVELOPMENT IN SOUTH AFRICA.—In his report for 1916 the general manager of the South African Railways and Harbours makes the following comments upon locomotive development:—The further improvement of the locomotive boiler is a subject that has engaged the attention of mechanical engineers for some time. The superheater has added greatly to the steaming efficiency, and has neutralised the difficulties associated with the firing of large engines to maintain the pressure of steam necessary for the work required of a modern locomotive. But increased steam pressures are still desirable, and experiments are being conducted in different parts of the world with new boiler designs and other improvements calculated to develop the steaming efficiency and the steam pressure of the locomotive. That very high pressures can be raised and maintained by means of tube or pipe generators has already been established, but it has yet to be proved whether a generator of this type can be successfully adapted to locomotive practice. A generator on these lines has been designed by the superintendent (mechanical), Johannesburg, and inquiries are being made as to the practicability or otherwise of his proposals. The design involves a radical departure from present practice, and will require most careful investigation and consideration before further action is taken. In the experimental stage oil fuel may have to be used, but the object in view is to adapt the engine to burn coal dust, and, that being so, the result of the advance that is being made in the United States with engines designed to use pulverised fuel is being watched with special interest, especially in view of the fact that the use of such fuel eliminates fire hazard.

THE TIGRIS FLOTILLA OF GUNBOATS.

CONSTRUCTED BY MESSRS. YARROW AND CO., LIMITED, SCOTSTOUN, GLASGOW.

(*For Description, see Page* 429.)

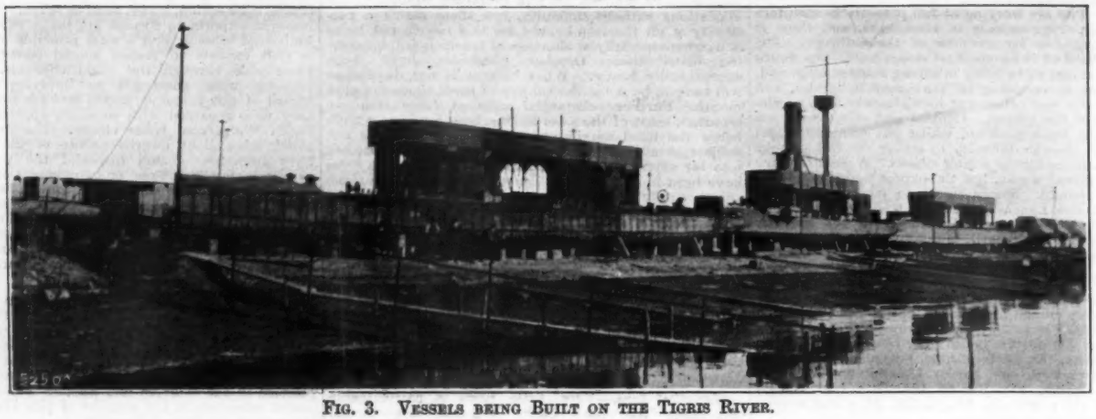


Fig. 3. Vessels being Built on the Tigris River.

Fig. 4. One of the Vessels Ready for Launching.

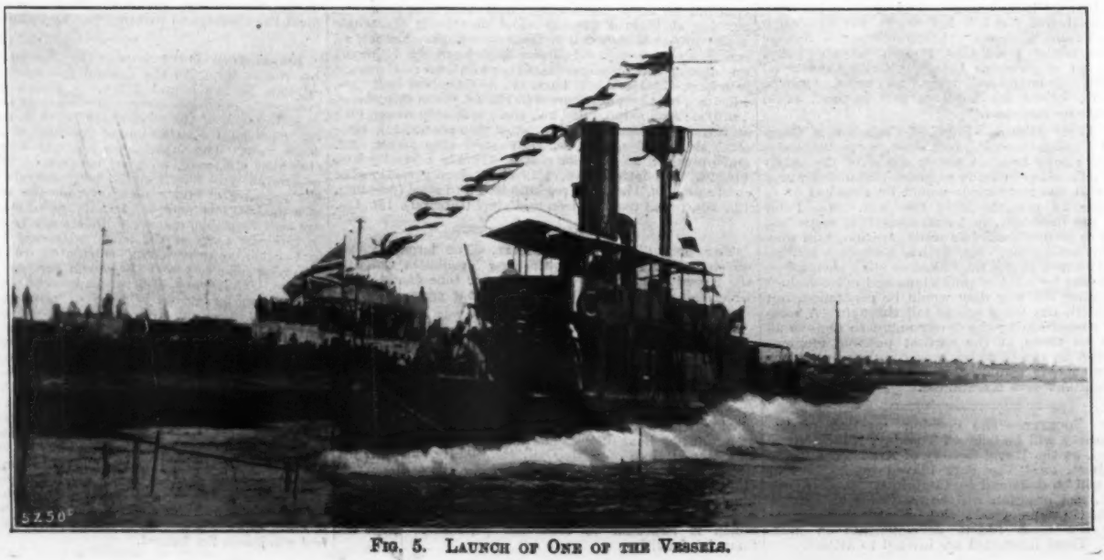
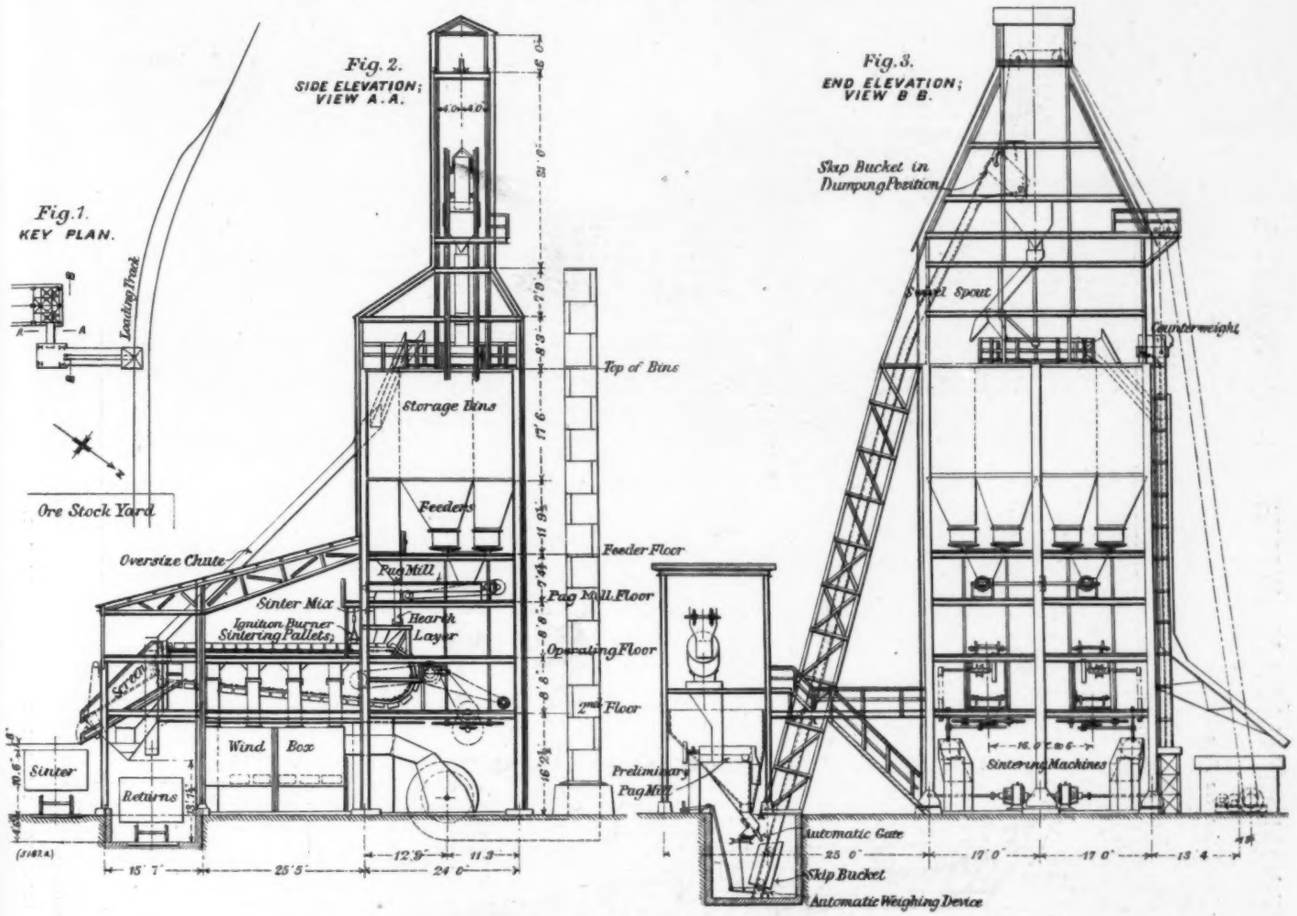


Fig. 5. Launch of One of the Vessels.

HANDLING MATERIALS AUTOMATICALLY WITH SKIP HOISTS.

(For Description, see Page 434.)



FIGS. 1, 2, 3. FLUE DUST SINTERING PLANT, WITH FULL AUTOMATIC SKIP HOIST.

FIG. 4. HOISTING ENGINE HOUSE AND COUNTERWEIGHT.

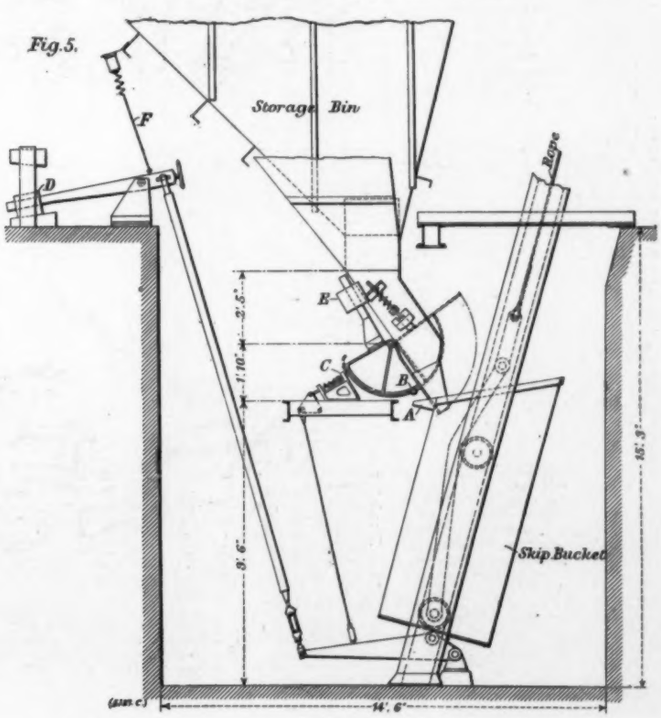
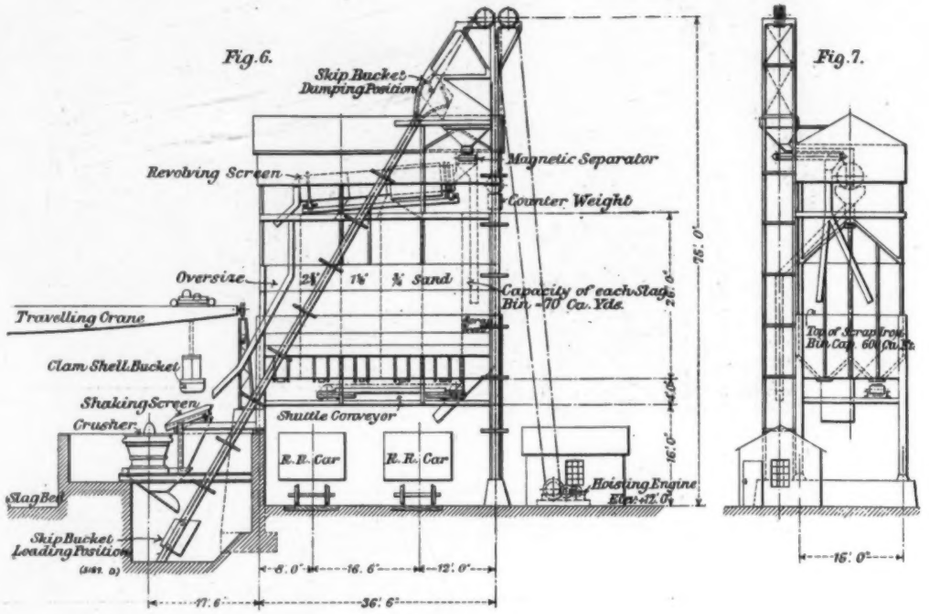


FIG. 5. COUNTERWEIGHTED LEVERS IN THE SKIP HOIST PIT.

(To face page 434.)

HANDLING MATERIALS AUTOMATICALLY WITH SKIP HOISTS.

(For Description, see Page 434.)



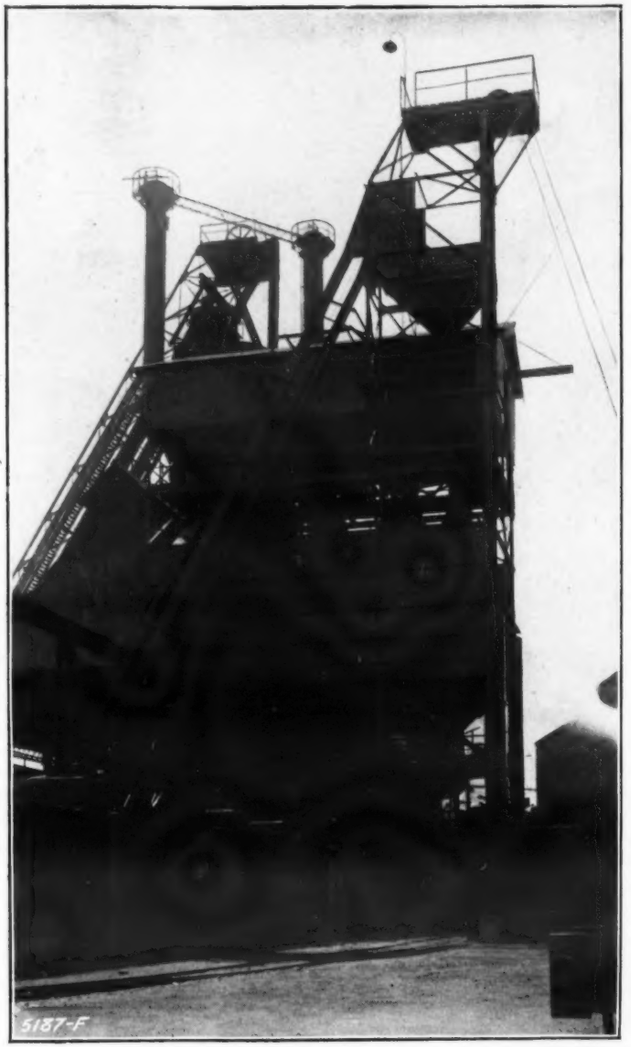
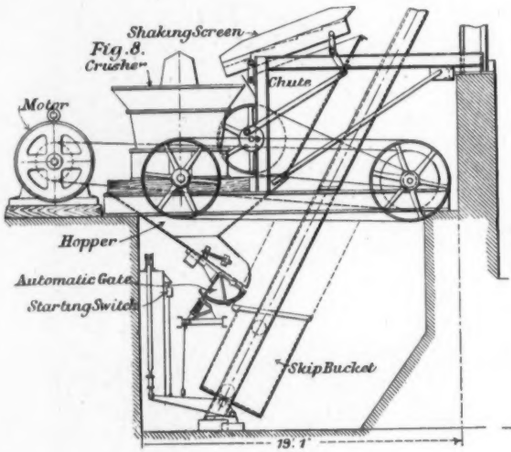
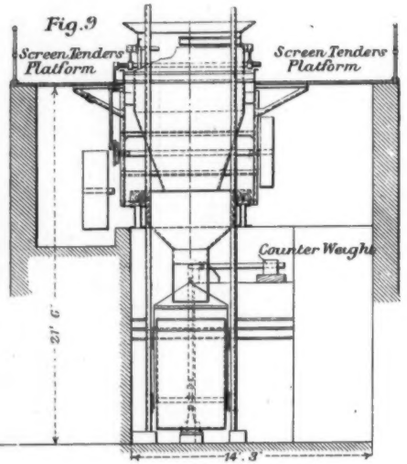


Fig. 10

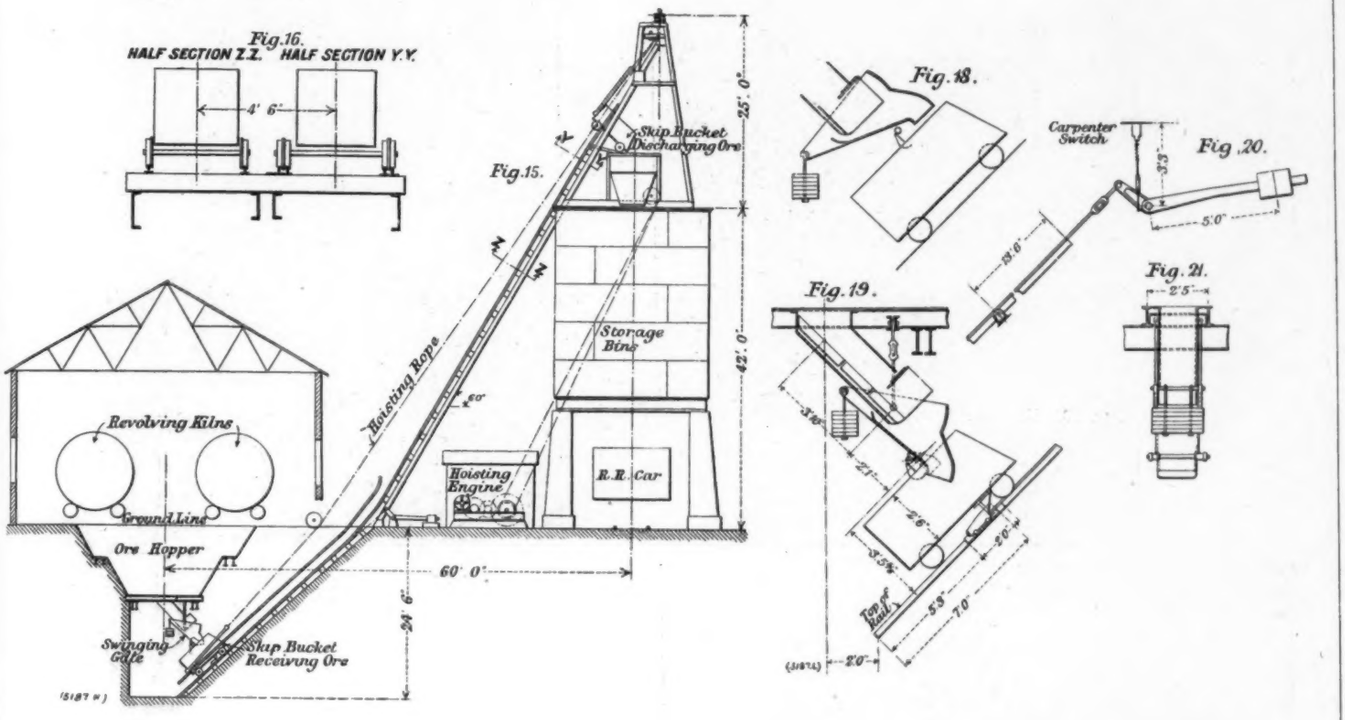




Figs. 6 to 10. Plant for Crushing and Classifying Blast-Furnace Slag.

HANDLING MATERIALS AUTOMATICALLY WITH SKIP HOISTS.

(*For Description, see Page* 434.)



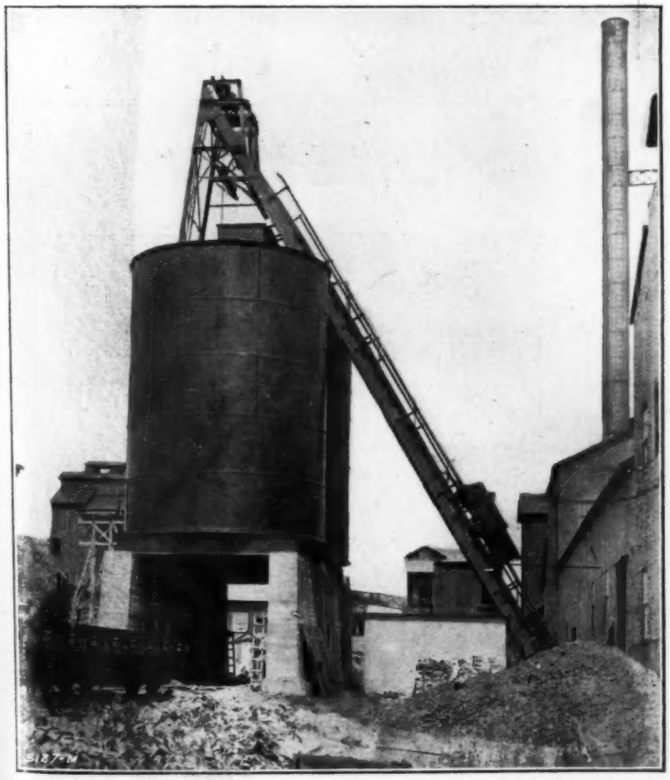


Fig. 17.

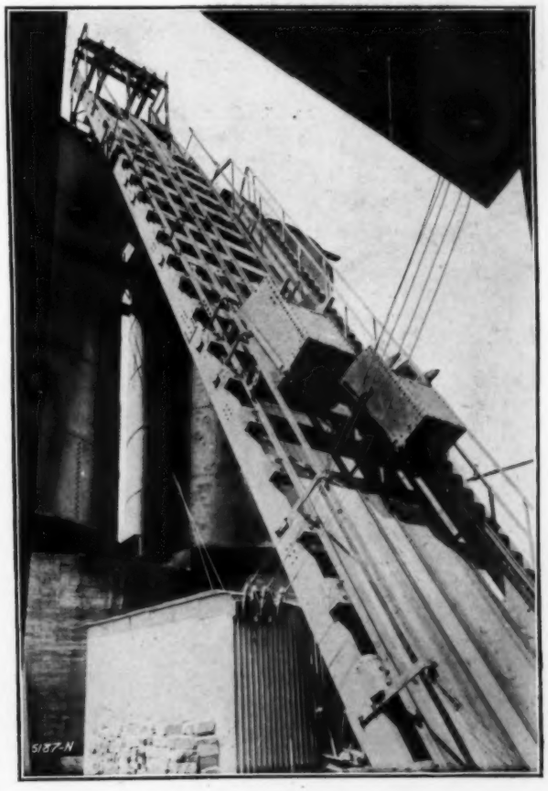


Fig. 22.

Figs. 15 to 22. Double Entirely-Automatic Skip Hoist Handling Hot Nodulised Ore from Kilns to Bins.

HANDLING MATERIALS AUTOMATICALLY WITH SKIP HOISTS.

(*For Description see Page* 434.)

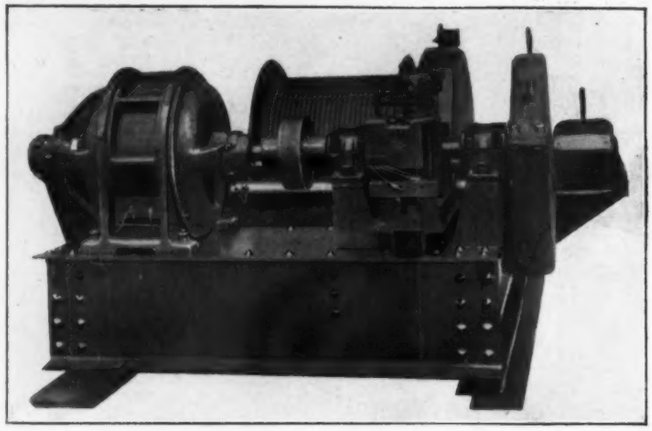


Fig. 23. Electric Hoisting Gear.

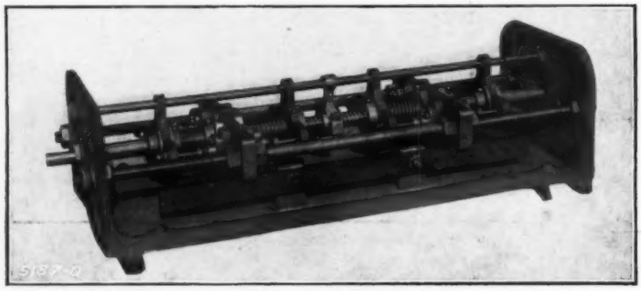


Fig. 25. Limit Switch.

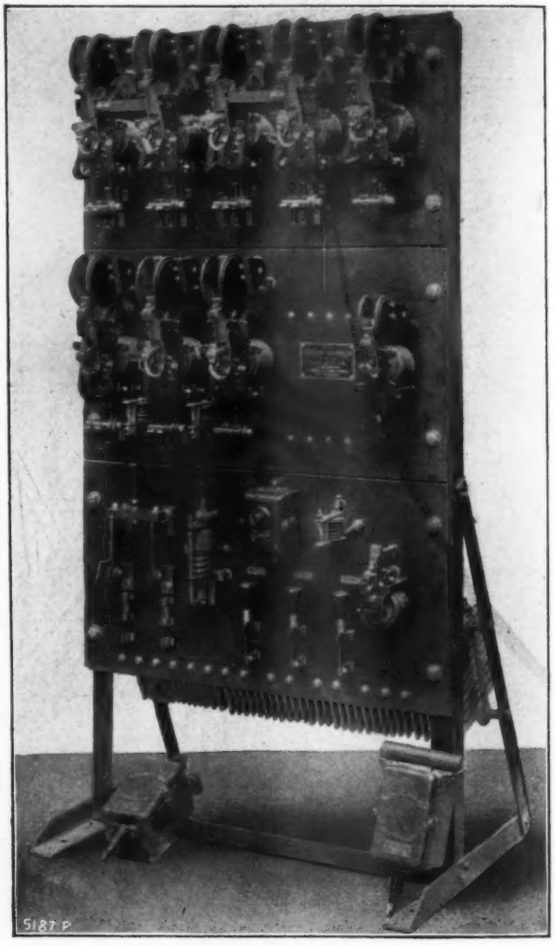


Fig. 24. Switch Panel.

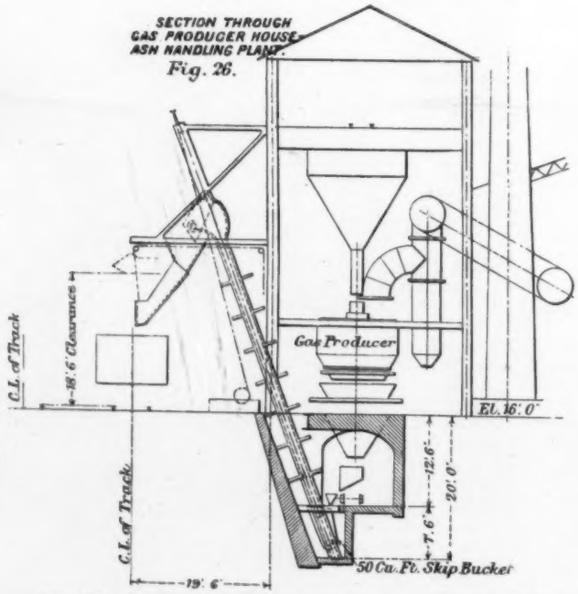


Fig. 26. Ash Hoist lifting from Gas Producers to Bin.

Fig. 27. Ash Hoist in Steel Works.

(*To face page* 435.)

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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TELEPHONE NUMBERS—3663 and 8508 GERRARD.

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NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, October 26, at 5 p.m., at the Imperial College of Science, Imperial Institute-Road, South Kensington, S.W. Agenda:—(1) "On a Class of Multiple Thin Objectives," by Mr. T. Smith, B.A. (2) "The Radius of the Electron and the Nuclear Structure of Atoms," by Professor J. W. Nicholson, M.A., D.Sc., F.R.S.

THE MANCHESTER ASSOCIATION OF ENGINEERS.—Saturday evening, October 27, at the Grand Hotel, Aytoun-Street, when a paper entitled "Worm Gearing" will be read by Mr. Francis J. Bostock, A.M.I.Mech.E., A.M.I.A.E., Huddersfield. The chair will be taken at 6.30 p.m.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Monday, October 29, at 7.30 p.m., in the Engineers' Club, Albert-Square, Manchester. Chairman, Mr. Robert Matthews, Member of Council. A meeting has been arranged for the presentation and further discussion of Mr. Oswald Wans' paper on "A Comparison of the Working Costs of the Principal Prime Movers."

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Saturday, November 3, at 3 p.m., at the Danum Hotel, Doncaster. The following paper will be read:—"On the Splitting of Coal Seams by Dirt Partings," Part I—"Splits that Rejoin," by Professor P. F. Kendall, M.Sc., F.G.S., Leeds. The following papers will be open for discussion:—"The Higher Education of Colliery Managers," by Mr. G. R. Kerr (Vol. LIII, Part 3). "Areas of Deposition of the Coalfields of North-Western Europe," by Mr. G. Blake Walker.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

ENGINEERING.

FRIDAY, OCTOBER 26, 1917.

THE HUMAN FACTOR.

THE business of an engineer is to deal objectively with material problems; his training consists in the acquisition of knowledge to this end. Curiously enough, the subject of labour is later to become almost the dominant and possibly the most troublesome of all his cares. Starting with a belief that his main object is the production of mechanism from material, he finds that, as time passes, he is much more concerned with finance, labour and the human factor—commercial or manual. He becomes more an administrator than a technical executive, realises that selection of subordinates and the will to work of his staff—both psychological problems—are more potent matters even than organisation and purchase of material. Human muscle—that is, its external appearance—is easily viewed, but the intelligence and capacity which, after all, animate it, are not so readily assessed. Capital and labour associated with system and organisation—the marriage of credit and muscle—is too often superficially assumed to be a profit-making co-partnership. Provided sufficient of either is available, there should be little difficulty in earning dividends seems a usual view. The human factor, however, permeates the entire structure, and unless duly assessed and rightly placed, the anticipated profits may vanish unaccountably into thin air. It is too little realised that while share capital is definite, each human unit is a separate personal identity afflicted thereby with common human disabilities.

In actual practice there is only one penalty for failure or infraction of discipline—dismissal. On the other hand, no firm can afford for trivial cause to deprive itself of the services of a potential profit-earner; it would suffer a greater loss than that immediately realised, as change disturbs the poise and balance of the machine. The power of inflicting the extreme penalty is therefore more or less judicially exercised; first thought is often tempered with discretion. The outcome is that the two things—power and penalty—tend to equate each other. The man is kept in check by knowledge of the penalty, the management, knowing the difficulty of adequate replacement, is none too ready to use its privilege. Fear on both sides helps to keep each virtuous.

Technical troubles are apt to cause less serious problems than the human factor. It is an incomparable asset to be able without resentment to get the most out of a working force; to possess the knack of so doing is not a common quality. To diagnose the slacker may be easy, to understand why he slacks not so simple, to apply the correct remedy more difficult still. It is safe to say that a policy of bluff or of blackguardism is as likely to be wrong as continuous nagging or fault-finding. To handle an awkward case by tact and firmness, by the hand of steel in the glove of velvet, requires experience no less than natural ability. Some men possess this happy faculty, which keeps a sore place from rankling. To drop heavily on the wrong man, or for the wrong matter in the wrong way, displays a want of judicial insight and is fraught with perilous results to output. A man flagrantly caught out will suffer remarks and feel their caustic justice without subsequent resentment. To use the same method for purely accidental fault is to invite shirking. We are, after all, each a member of a common human family, and whatever station we occupy our feelings are roughly equal. Any method whereby effort is induced is an end in itself worth consideration and some thought.

In normal times men often are hired, tried, and fired, at the wanton caprice of a technically capable but otherwise ill-equipped individual, because an excess supply of labour is available. With a restricted supply an explanation of the touchiness of labour complained of just now in some quarters is afforded. The men are not rightly handled. To keep a large staff working harmoniously to a single end demands administrative ability of a high order. Judicious and just handling is of prime importance, the appearance of injustice, no less than a flagrant case of it, must be strictly avoided.

Profit-making is the cream on the milk of industry, it represents only a fraction of the bulk turnover, and it may be forfeited in many ways. System and organisation is one part of the profit-earning mechanism, the correct handling of labour and its incitement to real effort are quite as important and not so apparent. To reach the desired end needs a judicial temperament coupled to an endowment of common-sense, scientific spirit and a frank recognition of labour's human structure.

There are productive and unproductive periods in each working day, alternations of normal effort and natural slackness. It is the dead centres which want attention, not the time of full crank effort. Conditions and environment have much to do with output. A difference of 10 deg. in temperature unrectified will produce remarkable results. Fresh air and light, the former costing nothing, do much to affect the total output. The human dislike of sheer monotony, its desire for rational change, are other questions for consideration. Piecework is one incentive, sheer interest in the job in hand another. If the shop recognise in its chief an able man, competent and efficient, the results will exceed those under the reverse conditions where and when they operate. Example does more than driving, as shown in the success achieved in many small concerns.

Production is a delicately-poised balance dependent upon quite small things, which in the aggregate are apt to turn the scale. Labour is generally found to be more troublesome where the supply is strictly limited; then the necessity for right handling is more acute, and as a consequence the result is usually better and the staff more satisfied. The inevitable result of scarcity is an increase in realised value; reduced supply may result in insubordination or, if the firm is wise, in improved conditions and better treatment. The intimate relation of isolated factory, scarcity of labour and welfare schemes point their own moral. The worst industrial conditions are found in large centres, where both man and management have a greater available choice. The necessity for better conditions is less apparent and certainly less realised. Labour trouble points to a lack of visualisation on the part of the management, to the desire on the part of the man to pick and choose, that is, to find an

open market for his skill, or to injudicious handling, pointing to faulty executive.

Belief on the part of the man that he will meet with rational justice from his employer who, he feels, is human and personally interested in his work, tends to retain skill and competency, even when offered better terms elsewhere. More than one highly qualified producer has failed because of his inability to understand men other than as numerals or portions of an essential mechanism. Exploitation or unfair treatment, or possibly dismissal for small reason in the case of a single individual, shakes the confidence of the rest; the co-ordination of a labour force and their dependence in daily work one on another lend fatal prominence to a seemingly minor issue. A small grievance is like a gear wheel with a damaged tooth, which disturbs the smooth running of the train. The hostility and independence shown in labour troubles, the divorce of the men from the interests common to the firm as a whole, have been at least partly made and fostered by such causes. Confidence once lost is not easily restored. Like reputation, it represents a solid asset, and any effort to engender more cordial relations is worth the making, while the result is likely to be more beneficial than is often realised and well worth the trouble involved.

THE TREATMENT OF SEWAGE BY AERATION AND ACTIVATED SLUDGE.

The method of treating sewage by aeration and activated sludge has awakened a great and increasing amount of interest. Evidence of this is to be found in the articles we have recently published, describing the latest developments of it both here and in America.* But in spite of such knowledge as we now possess it would still appear difficult either to assign it a definite value as a scientific process, or to dispute the claims which have been put forward as to the possible results of its operation.

The changes in the character of the sewage necessary to attain ultimate purification are brought about by the natural action of organisms working under an aerobic condition, and are consequently effected with freedom from offence. The effluent discharged is highly nitrated, while the sludge, owing to the removal of colloids and other non-settling matters, contains a larger percentage of nitrogen than that resulting from older methods of treatment. This method also admits of ready adjustment to the varying strengths of sewage, or the degree of oxygen dissolved in the river water into which the effluent is discharged.

But while appreciating the possibilities of this process, it is impossible to deny that its adoption as a workable method of sewage disposal is still open to proof. Apart from any return which may be obtained by converting the sludge into a fertiliser (an operation which its larger nitrogen contents would appear to make commercially possible), it is likely to prove more costly than that effected by a combination of tanks and filters; the operation is a delicate one, demanding skilled supervision; the sludge contains a high percentage of moisture; rapidly returns to a putrefactive condition, and increases difficulties of disposal, which at some works are already sufficiently great; and although with dilute sewage or one free from discharges of trade effluents uninterrupted working may with proper care be anticipated, in other cases serious breakdowns may occur, apart from arrangements for equalising or neutralising the sewage.

While the question of cost is, of course, important, it would appear unwise to consider expense apart from the special advantages which may be gained by the adoption of this method of treatment, such as freedom from offence or the comparative smallness of the area of land required. Moreover, it is reasonable to anticipate improvements, both in design and methods of working, which may tend considerably to reduce the cost of operation. More serious objection to the ready adoption of this form of sewage treatment arises from the evident delicacy of the operation and the demand for the exercise of a degree of care not always associated with sewage disposal works.

This delicacy is evidenced in the ease with which interruption in working may be brought about. The more common causes of interruption are the careless discharge of trade effluents; the over- or under-activation of the sludge; the clogging of air-diffusers, and the return of putrefactive sludge to the aeration tank. The first cause is common in a degree to all biological processes, but whereas in older methods of treatment opportunities for equalisation in tanks in connection with preliminary treatment is generally afforded, in this method no protection was given in the earlier plant and serious breakdowns occurred.* At Sheffield the tanks went out of action for several weeks owing to a discharge of acid waste.†

The Milwaukee experiments show that over-activation of sludge may be caused by (*a*) the particles being broken up by excessive aeration, by (*b*) the saturation of the gelatinous surfaces with grit, which the passage through the grit-chamber has failed to remove, or (*c*) by the material within the particles being "burnt-up," the consequent result being a failure to stimulate bacterial growth. Inadequate aeration, on the other hand, may result in under-activation, and in this connection it is necessary to note that interruption in working arising from such causes amounts to more than mere suspension in operation, it involves a "falling back," the sludge having to be thrown aside or reactivated, and in the absence of a reserve of matured sludge serious delay has to be faced.

A further and frequent source of interruption is met with in association with air distribution. The maximum efficacy of the process is dependent upon the fineness of the air bubbles which are forced into the sewage, and hitherto the degree of fineness desirable has only been obtained by the use of porous plates, in the use of which it is difficult to avoid clogging by dust particles, apart from the costly process of washing and filtering the air, while further trouble may arise from the deposition of solids on the surfaces of the plates (owing to insufficient screening or grit removal), from bacterial growths, or from fine hair or fibre associated with certain manufactures. These troubles are unfortunately accentuated by the position of the plates in the tanks and the consequent difficulties of cleansing.

Waste of air may also occur from "streaming," owing to unequal porosity in the structure of the plates used.

Difficulties of this nature can be largely overcome by the use of perforated pipes, which, while involving a certain loss in efficiency, save the cost of filtering and washing the air, while at the same time permitting a reduction in air pressure. When air-blowing is intermittent and pipes are employed, arrangements for raising and lowering the apparatus for cleansing would seem possible. Trouble consequent upon the return of sludge when in an unfit condition to aeration tanks will doubtless be overcome by improvements in the design of settling tanks. This point is met in the design on page 118 *ante* by the sludge being reaerated between the settling tank and the aeration tank. The difficulty arising from bulk of sludge, consequent upon the high percentage of moisture which it contains, becomes a serious one where the only method of sludge disposal consists in its speedy removal from the treatment area. Where a considerable area of land is attached to the works the sludge may, during seasonable weather be run on to the land and deposited in thin layers, where it dries without offence, or where such land is under cultivation the sludge may be immediately used for fertilising purposes during certain periods of the year. Apart from such methods, it can be resettled and de-watered (a process, however, which cannot be carried too far, owing to the before-mentioned tendency to return to a putrefactive condition) and then re-aerated, the life of the organisms in which it abounds being maintained until matters of a putrefactive nature are fully digested; or, finally, it can be converted into a fertiliser by pressing and treating in a drier. American experiments in this direction tend to show that: (*a*) it readily dries; (*b*) a large amount of power is not required; (*c*) little, if any, nitrogen is lost during the operation. Such experiments also show that the sludge can be handled by presses without the addition of lime, and pressed down to 75 per cent. moisture without much difficulty.

It has been suggested that activated sludge may be de-watered by the Dickson process, which consists in adding yeast to the sludge (after a proportion of its moisture has been withdrawn by sedimentation), and allowing it to ferment in specially heated tanks, the intensity of the action giving buoyancy to the sludge and permitting the underlying water to be drawn off, but there appears to be no record of attempts in this direction.

An interesting paper, read by Mr. Edward Ardern, M.Sc., before the Society of Chemical Industry, at Birmingham, some few weeks ago, contains a review of work carried out in connection with this method of treatment, both in this country and America, and further refers to preliminary operations to be observed, and details in design and working which should be followed in order to ensure more perfect and economical results. The necessary removal of excessive quantities of oily and all heavy suspended matter; the provision of reaerating tanks; the form of aerating and settling tanks, as tending to efficient aeration, or as likely to prevent the return of sludge in a more or less putrefactive condition, together with a possible reduction in volume of air required by the introduction of pulsating gear, are matters which are duly receiving attention. Considerable advance has undoubtedly been made already towards perfecting and rendering workable this singularly inoffensive method of treatment.

* "Sewage Aeration and Activated Sludge"; page 16 *ante*. "Activated Sludge Process of Sewage Purification at Worcester"; page 49 *ante*. "Activated Sewage Purification Plant for a Government Factory"; page 118 *ante*. "A Comparison of the Activated Sludge and the Imhoff Tank-Trickling Processes of Sewage Treatment"; pages 288 and 319 *ante*.

* The installation described on page 118 *ante* has a preliminary balance tank.

† Sheffield sewage is at all times difficult to treat, as one-fourth of the dry-weather flow consists of trade effluents.

THE HARDNESS OF ALLOYS.

In continuation of his systematic investigation of the hardness of metals and alloys, Professor P. Ludwik, of the Vienna Technical High School, has been preparing alloys of two and more metals in varying proportions and submitting them to the Brinell hardness test. He forces a cone of an angle of 90 deg. into the metal. The figures of his comparative tables refer to a load put on for one minute, and the hardness figure arrived at represents P/f, where P is the load in kilograms and f the area of the compression circle in square millimetres. For the tests, however, the rate of load application varied with other conditions. Especially in pure metals and soft alloys the rate of loading is of great influence. He prepares his alloys from electrolytic copper and commercially pure other metals, and measures the hardness both of the quenched specimen and of the specimen heated for 3 hours nearly up to the lower solidification point. The melting mass is stirred with electrode carbon and poured into an iron mould of 25 mm. wall thickness; as the specimen itself has a thickness of only 7.5 mm., being 30 mm. wide and 150 mm. long, the quenching is very rapid. The comparative hardness determinations are made soon after pouring, because some alloys change in the course of time. The researches so far published (*Zeitschrift des Vereines Deutscher Ingenieure*, June 30, 1917, pages 547 to 554) deal with copper, tin, lead, zinc, aluminium and their alloys with one another and with other metals.

In the case of copper addition of 1 per cent. of tin increases the hardness by 10 per cent.; 10 per cent. Sn increases the hardness of copper to twice, 15 per cent. to three times its value (gun and bell metals); annealing of the bronzes does not affect these figures much. The further addition of zinc to Cu-Sn further increases the hardness of the bronze, but much less than tin would do. Zinc alone added to copper augments its hardness slightly, but with 35 per cent. of Zn the hardness curve of the alloy rises suddenly (malleable brass). The hardness of brass is increased more by the addition of Sn, and also of Al (durana metal), than

that of copper is; such brasses are more brittle, however, and become soft on annealing. The addition of up to 8 per cent. of aluminium exercises little effect on the hardness of copper; higher percentages of Al are more effective than Sn. Nickel hardens copper less than Sn and Al do, manganese ranks between Ni and Sn in this respect, 15 per cent. of Mn being equivalent to 5 per cent. of Sn. Both lead and bismuth decrease the hardness of copper. Magnesium proves by far the most effective hardener of copper and of all the other metals investigated, surpassing Al especially in so far as it has a strong influence already in small percentages. This strong hardening influence of magnesium, and also of aluminium Ludwik connects with their "efficacity," which he defines as the number of atoms of the dissolved metal per unit volume of solvent metal.

The hardness of tin is increased to twice its value by the addition of up to 15 per cent. of lead; more lead makes the tin softer (soft solder). Copper has a stronger hardening effect ont in than lead in all proportions; antimony behaves like copper, and 15 per cent. of Cu or of Sb impart to tin three times its original hardness. Both Cu and Sb together (bearing metal) have a still greater hardening effect; antimony and much lead added together give a softer bearing metal. Magnesium and aluminium have very strong effects; 0.5 per cent. of Mg makes the tin twice as hard.

Lead is, of course, hardened by the addition of antimony; 1 per cent. to 8 per cent. of Sb increases the hardness threefold, 15 per cent. to 30 per cent. of Sb fivefold. Tin also hardens the lead, but much less; in ternary alloys of Pb-Sb-Sn the effect of Sb shows only at high percentages. Bismuth ranks below tin as hardener of lead. Cadmium has a much stronger action, surpassing even antimony, and magnesium again the strongest; 0.5 per cent. of Mg increased the hardness of the lead threefold.

As regards zinc, the presence of a little lead or tin renders the zinc only a little harder; higher percentages of Sn make zinc (and also aluminium) softer. Ternary alloys of Zn-Sn with copper or aluminium, and quaternary alloys with copper and antimony, show this softening in a more pronounced way, whilst addition of antimony and especially of copper to zinc renders the zinc harder; zinc with 4 per cent. of Cu has twice the hardness of zinc. Annealing effects little in these cases. An addition of 0.25 per cent. of magnesium hardens the zinc as much as 4 per cent. of copper. Cadmium stands next to Mg as a hardening agent of zinc; but the hardening effect of Cd reaches its maximum with only 4 per cent., and the aluminium curve resembles that of cadmium in alloys with zinc.

Aluminium itself is little affected in its hardness by the addition of tin, above 4 per cent. of which rather softens the aluminium. Copper hardens the Al, but Al-Cu is little influenced by tin as to hardness. Zinc has likewise a hardening effect on Al, weaker than that of copper, however. Magnesium proves also the most efficient hardening agent of aluminium (magnalium); yet its effect in ternary alloys is less pronounced than it is in the case of other metals. All the same, the alloys of Al with Cu and Mg and, further, with manganese (duraluminium) are very hard, and annealing further increases the hardness of these alloys, as also of the binary Al-Zn and Al-Cu alloys. There is finally a gradual increase in the hardness of Al-Cu alloys, amounting, *e.g.*, to 17 per cent. when they are kept for three weeks at ordinary temperature.

Glancing over these tables and curves one notices many peculiarities, and Professor Ludwik asks, for instance, why cadmium should sometimes, but not always, resemble magnesium and aluminium as a hardening agent. But impure metals and experimental conditions might account for some anomalies, and the whole subject is not yet ripe for generalisations.

NOTES.

The Swiss Federal Current-Meter Testing Station.

Up till 1896 Switzerland possessed only one institution in which current-meters could be standardised, namely, the testing laboratories of Messrs. J. Amsler-Laffon, the well-known hydraulic engineers of Schaffhausen. The Federal authorities then entrusted all questions concerning water and hydraulics to the hydrometric department, which in 1908 was enlarged into the department of hydrography. Since 1896 the official testing of current meters had been conducted in Papiermühle, near Bern; this station was rebuilt in 1915, and a brief description of the station, based upon a pamphlet by Messrs. W. Kummer and O. Lütsch, is given in the *Schweizerische Bauzeitung*, of September 29, 1917. The instruments are standardised with the aid of an electric carriage running at variable speeds over an open tank or conduit of still water. The conduit has a length of 172 m. (565 ft.) and a depth of 1.20 m. (47 in.); the width increases from 1 m. (40 in.) at the bottom to 1.20 m. on the top. The track, of Vignole rails, in sections of 10 m., 95 mm. (3¾ in.) high, rests on the tank walls, which, at both ends of the conduit, are slightly inclined at a gradient of 40 in 1,000, in order to facilitate both the starting and the stopping of the carriage. The carriage resembles a small-size tramway car, and its speed can be varied at will from 0.02 m. up to 6.22 m. per second. This variation is obtained with the aid of the Ward-Leonard motor regulation and a change-over gear. As the speed of the motor shaft is raised from 115 to 2,300 revolutions per minute the speed of the driving axle rises from 0.76 to 229 revolutions per minute. The electric equipment on board comprises the main monophase motor for 7 h.p., joined to the line, a Leonard generator with special exciter, a Leonard motor coupled with the driving axle, and a second shunt exciter for an oil-servomotor which regulates the resistance of the field of the driving motor.

Titanium.

Titanium is metallurgically somewhat in the position which aluminium occupied forty years ago. Very widely distributed, though not generally in large deposits, titanium might be utilised in various ways if the smelting difficulties could be overcome. Chemically titanium stands between carbon and silicon on the one side, and zirconium and the rare earths on the other. It occurs mostly as oxide, TiO_2, alone as rutile, or associated with iron as ilmenite, $FeO \cdot TiO_2$. The chief European deposit is at Kragerö, in Norway; very large deposits of ilmenite are found in the Quebec Province (near Rapid River and Saguenay River), in the United States, India, Ceylon, Nigeria, Queensland and South Australia. The titaniferous iron-sands abounding on the shores of Taranaki Bay, New Zealand, first attracted attention in the British Colonies; but they are unsuitable for the blast-furnace, and even the quite recent attempts at briquetting the ore and smelting it in electric and other furnaces have hardly been successful so far, as we see from the Bulletin of the Imperial Institute, vol. xv, No. 1, 1917, which contains a very instructive article on "The Distribution and Uses of Titanium Ores," amply stocked with references. The pig-iron from the titaniferous sands is too rich in phosphorus and sulphur. Earlier attempts made at Norton, in England, to smelt titaniferous iron ores were given up, owing to the pasty condition of the slag and the uncertainty of the ore supply. That uncertainty does not exist at Sanford Hill, in the Adirondacks (New York) and in the Iron Mountains of Wyoming; but the smelting is not prospering, and the replacement of the silicon in the iron by titanium is not liked. Yet rail steel is notoriously improved as to strength and abrasive resistance when about 1.7 lb. of titanium (as iron alloy) is added in the ladle per ton of steel; and ferro-titanium was much used for this purpose in the days of Bessemer steel, though the metal had to be reduced by the aid of aluminium. The action of titanium, which binds the nitrogen in iron to a nitride, is said to be less marked with open-hearth steel; but basic steel has been improved in this way at Osnabrück, at any rate. There are other uses of titanium. The metal filaments have been superseded by tungsten. But the General Electric Company makes arc electrodes of titanium carbide or of a magnetite containing 20 per cent. of titanium; yellow titanium pigments are appreciated in ceramics and mixed with asphalt as rust-preventing paints; titanium salts give superior mordants in the textile and leather industries, and the nitride, we may add, is a promising refractory material.

Women and Munitions.

The exhibition of women's work which the Ministry of Munitions is giving in the principal industrial centres has now been transferred to Birmingham, where it was opened on the 22nd inst., at the Art Gallery, by the Lord Mayor, in the presence of an audience of 1,500 representatives of local manufactures, including over 300 works managers. This exhibition will remain open for three weeks, and is being supplemented by cinematograph demonstrations on Sunday evenings at the Scala Theatre, showing women in the act of manufacturing a variety of munitions in this country and in France, and some scenes of actual warfare on land and at sea. At the meeting on the 21st inst., at which Professor Sir W. J. Ashley presided, Mr. Morgan gave an address on women's work in the war. The audience was composed entirely of those engaged in the munitions industries. Over 30,000 applications had been made for tickets; and the interest taken in these demonstrations may be estimated alternatively by the fact that since the meeting of the 21st inst. a number of firms have applied for the loan of the films in order, at their own expense, to take theatres near the works and give special displays to their workpeople. It is to be hoped that the fuller knowledge of women's work which these exhibitions are conveying where it should be the most useful may assist in their wider employment, and lead to remedying the inequality in their employment, for which the country will pay a long and a dear price as long as it continues. An account of the exhibits will appear in our next issue; but in the meantime we may draw attention to the captured aero engines and the Clerget engine, which were exhibited at Sheffield and are shown again in the present exhibition. We have asked plainly (Engineering, October 5) certain questions on the present position of the design and manufacture of aero engines. British and French practice have given to aircraft a number of beautiful but complex types of engine, while Germany has found herself able to adopt what apparently are standardised designs based on well-verified motor-car practice, and seems to be producing them by methods of intensive manufacture in which full use can be made of semi-skilled labour. We believe that grave issues depend on the ability of the authorities to give satisfactory answers to the questions that we have asked. Their bearing on the present situation will be obvious to all engineers; and delay in giving the simple assurance that has been asked, an assurance that represents merely the measures that elementary administrative prudence demands, would give ground for serious apprehension.

Instability of Electrified Liquid Surfaces.

When commenting on the difficulties of imparting an electric charge to gases in his lectures on "Electrical Properties of Gases,"* Sir J. J. Thomson stated that the vapours of ether, rising from a warm, electrically-charged plate of brass, or mercury vapours given off by a layer of electrified mercury, did not carry any electric charges away with them. Though Sir Joseph did not state a new fact, the statement sounds rather surprising. Some recent experiments made by Professor J. Zeleny, of Yale, though not disproving the fact, show, at any rate, that an electrified liquid surface is in an unstable condition. Zeleny (*Physical Review*, July, 1917, pages 1 to 6) experiments in the following way. He charges a vertical glass tube, 0.92 mm. in diameter, with a liquid (generally alcohol, water is not so suitable) by connecting its upper end with a reservoir of the liquid, and he adjusts the hydrostatic pressure in such a way that drops form at the lower opening of the tube and fall off at a slow rate. The liquid is now charged to a potential of 5,000 volts or more by means of an induction machine, and an earthed metal plate is placed about 2 cm. below the end of the tube. The drop then becomes elongated, more cylindrical than it was, and the instability manifests itself by the formation of a thread of liquid, which hangs downward like a tail, breaks off and

* See Engineering, May 11, 1917, page 456.

contracts into one or more little drops, far smaller than the original drop. Sometimes several tails appear simultaneously. Better to study the phenomena, Zeleny took photographs of the drops at intervals of one-eightieth of a second with the aid of an induction coil circuit comprising a Leyden jar and a mercury jet interrupter. The fine photographs reproduced in the paper enable the reader to watch the phenomenon. There is generally an asymmetry. The thread or tail into which the drop is drawn out appears, say, on the right of the tube and is deflected to the right; on the next photograph the thread, resembling a long, thin cigar, pointed at both ends, has left the tube, and is moving downward, obliquely to the right; then it contracts into two small drops which, in the next picture, unite to one bigger drop, much smaller still than the original drop. The drop then develops a new tail, this time on the left side of the tube and inclined to the left; and so it goes on alternately, the threads being occasionally also vertical. Sometimes the lower ends of the long, then very fine, threads were twisted into loops, breaking up into several drops. Zeleny also observed a drop of the shape of a perfectly symmetrical cone which narrowed down to a thread, only 0.004 mm. in thickness, and then spread out again in a big inverted cone or fan. The simultaneous formation of several threads was noticed particularly with higher potentials, above 5,000 volts; Zeleny speaks of eight and more threads or jets, which in this case appeared stationary for a little while, surrounding the end of the tube like divergent rays. When the liquid in the tube was glycerin, a fine vertical thread formed, which attained a length of 15 mm. before it broke up. This thread was of uniform thickness, whilst the others looked more like tiny cigars, as we mentioned. The rate at which these threads formed was 3 mm. per second. If any asymmetry should develop anywhere, the electric fields would be disturbed and give rise to further asymmetrical effects. Zeleny mentions, in conclusion, that the old experiment of threads being pulled from highly-electrified molten sealing-wax would doubtless be an example of the action described.

THE INSTITUTION OF MECHANICAL ENGINEERS.

An ordinary general meeting—the first of the session—of the above Institution, was held on Friday last, the 19th inst., at 6 p.m., at the Institution of Civil Engineers, Great George-street, S.W., the chair being occupied (in the unavoidable absence of the president, Mr. Michael Longridge) by Mr. Henry Davey, vice-president.

The chairman first made reference to the death of Mr. Percy G. B. Westmacott, who was president during the years 1883 and 1888. In our issue of September 21 last, page 286, we published an obituary notice of Mr. Westmacott, and in the following issue a portrait. The secretary then read the names of the 29 members of all classes who had died on active war service since the opening of the last session, in October, 1916.

Working Costs of Prime Movers.

The ordinary formal business having been despatched, a paper entitled "A Comparison of the Working Costs of the Principal Prime Movers," by Mr. Oswald Wans, member, of Lincoln, was read in abstract by the author; and as this is printed in full on page 451 of the present issue, we now proceed to deal with the discussion.

The chairman, in declaring the discussion open, suggested to the author that he should compile a table, by way of appendix to his paper, giving details of the basis of calculation for the curves submitted. Mr. Wans had assumed various efficiencies in relation to steam engines of which no details had been given, and the same remark applied to the producer in the case of the gas engine. The speaker thought that the particulars for which he was asking would form a very valuable addition to the paper. (Mr. Wans here expressed his willingness to comply with the chairman's request.) Mr. Davey, continuing, pointed out that the author had observed that most of the factors dealt with in the paper were varying ones, and Mr. Wans had endeavoured, as far as possible, to guard the statements he had made from being applied universally. It would be folly to determine merely from the author's curves the prime mover adapted to a special case without taking into account the various other factors, which not only varied in themselves but were affected by circumstances. An engineer might recommend the adoption of an engine that was not of high economy for reasons connected with a saving in capital expenditure, which might be a more important factor than any other. Again, the purpose for which the engine was required might not be continuous. Another circumstance in the case might be the impossibility of finding the necessary capital for the application of the most economical engine. The author had recommended a depreciation rate of 8 per cent. per annum, and had been somewhat prophetic in regard to the supersession of existing engines by others of a more economical character, assigning 12½ years as the probable period of service. There might be many cases in which it would be wise to scrap an engine after that lapse of time; but the speaker did not consider that generally the proposition was financially sound. Members would recall the prophecy of the late Sir Frederick Bramwell to the effect that within fifty years from the time of making the prophecy there would be no steam engines save those in museums. To-day there were more steam engines in existence than when Sir Frederick spoke. Referring again to the suggested reservation of 8 per cent., most commercial concerns would find it difficult to provide more than was necessary to cover business fluctuations and general depreciation, these matters being dependent upon the nature of the business. There were two ways of dealing with the 8 per cent. reserve. It might be put aside annually, and, if it were not to remain idle, be reinvested; or it might not be provided at all, and at the end of the 12½ years new capital would have to be created for new plant. In that case the new capital and the earning value of the new plant over and above that of the scrapped plant must not necessarily be 8 per cent.; it would be limited by the percentage dividend paid to the shareholders; the new capital would require, like the old capital, the payment of a dividend. Commercial people would prefer to raise new capital for new machinery rather than reserve 8 per cent. per annum. The question was, in fact, less an engineering than a financial one. The author assumed that the life of each plant, steam, gas, &c., would be the same for the particular purpose, and in this connection Mr. Davey considered that the 3 per cent. depreciation—ordinary depreciation—which the author recommended for all the different plants under consideration would have to be varied. Comparing such extreme cases as the Diesel engine and the steam engine, the speaker supposed that the steam engine had a life ten times as great as that of the Diesel engine; certainly it had a far longer life than the gas engine.

Mr. C. E. Stromeyer observed that many of the points raised in the paper required a great amount of detail for thorough understanding. He had considered two of these points, and from the work he had done in relation to them, he could fully appreciate the great labour which the author must have undergone in preparing his paper. One of the questions which he (the speaker) had tackled was the steam-producing power of a certain number of square feet of boiler space, taking various types of boilers. In the case, for instance, of the Lancashire boiler, with economisers, he found that 11 lb. of steam could be produced per square foot per hour, while with some types of water-tube boiler 30 lb. of steam per hour could be produced. Where floor space was of little value, and a new boiler-house could be built just outside a factory, the matter was unimportant; in planning a factory, therefore, the floor space for boilers was not a serious consideration. When, however, a factory was once built, and it was subsequently desired to alter the plant, the question of space assumed great importance. He had got out a few figures which he would present in a simple form for easy calculation. He would take it that a factory had been built at a cost of 100,000*l.*, that it occupied an acre of land, the land costing 1,000*l.* The space required for the boilers would cost about 60*l.*—a very trifling matter in relation to capital expenditure. It might happen that the concern was doing well, and paid a 10 per cent. dividend, or 10,000*l.* After a while, however, a new engine or power arrangement was devised which reduced the space occupied by power plant to one-half, so that instead of 6 per cent. the space occupied would amount to 3 per cent., leaving 3 per cent. to be used. Mr. Stromeyer was acquainted with factories wherein one or two boiler-houses were standing quite empty; but as soon as the war was over these houses would be converted into sheds for further spindles. The extra space in this instance would bring in 300*l.* per annum, the capitalised value of which, at 5 per cent., would be 6,000*l.* Therefore, in the case of a factory once built, and having no chance of expansion outside, this question of floor space became one of great importance. In connection with the question of renewals the author had suggested that these should be undertaken when a certain economy was obtainable. From estimates made by the speaker he would say that during the last thirty or forty years the economy of the steam engine had been improved by one-half. He supposed that this increase had been effected in successive stages; an improved economy of 10 per cent. might be said to have been obtained every six years. The question was, would it be right to scrap the existing plant every six years and put in new machinery? Ten per cent. was well worth considering, especially in the case of such a factory as he had mentioned. Yet certainly the directors of the concern would not tolerate such an alteration every five or six years.

With regard to repairs and upkeep Mr. Stromeyer mentioned the fact that some years ago he had occasion to survey certain ships owned by foreign countries. In some of the foreign countries there were good engineers who kept their ships in perfectly good condition, but in others this was not so. In one case, in particular, he believed the engines had never been opened up from the day they were supplied by the builders until they came back some four years afterwards. Their condition might be imagined. The piston rings were absolutely solid, and the whole engine was in an awful state. A great deal of money was spent in putting things right. The author had quoted 3 per cent. for insurance in the case of the Diesel engine, and, while he was aware that Diesel engines were frequently overhauled, he believed that if owners would, instead of insuring against breakdowns, have their engines surveyed more thoroughly, insurance costs, especially in the case of internal-combustion engines, would rapidly sink. One of the chief causes of breakdown was the fracture of pistons and crankshafts. While the speaker was at Lloyd's he had detected sixty flawed crankshafts; they were duly noted, but were not always removed at once, although they had very soon afterwards to be renewed. He regarded the 3 per cent. insurance charge for engines of the class under consideration as excessive. Here the speaker referred to what had been done in the matter of boilers. The principle laid down by Fairbairn was that boiler explosions could be prevented by more frequent and thorough inspection. He might say that the system of insurance and inspection with which he was connected was an excellent one, and that the sum for which compensation had been paid on accidents during a period of fifteen years before the war worked out at 6*d.* per annum per boiler, a figure which showed what thorough inspection would do. He might cite a further instance in support of the need for inspection. It was a case in which five boilers had been installed, and had to be supplemented by another because they could not do the work required. In the result the coal bill went up, while the power seemed to go down. The assistance of the speaker's association was sought, and the cause was found to be neglect of the flues, which were choked up. Personally the speaker disliked associating insurance with inspection, but as an instance of how insurance worked he might state that in America there was no association which corresponded to those in this country whose first duty was to inspect. The American boiler insurance companies published at intervals a leaflet

as to the number of boiler explosions, the standard being apparently the number of deaths caused. In England, for insured and inspected boilers, there were 10 deaths per annum, as against 200 in America. That illustrated the significance of inspection.

Mr. W. A. Tookey referred to the author's contention that comparisons of engine performance should be based on "everyday" performances and not on "kid glove" tests. The rule was an excellent one, but the speaker joined the chairman in inquiring about further details, so that the figures on which the author based his charges might be known. With regard to overload, it was necessary that engineers should agree among themselves as to the rated working load for any particular engine; this rated working load had not yet been specified for the different classes of engines mentioned in the paper. Mr. Wans had certainly suggested that if a gas engine of 100 h.p., to compare with steam engines, was required, it would be necessary to have one of 135 h.p.; but was it correct to use, on a technical and engineering basis, rated working load on brake horse-power? Why not say that for the mean working load which experience had shown to be right, so many cubic feet of piston displacement per minute should be allowed—or some such basis, which could easily be noted from manufacturers' lists? As matters stood, some manufacturers worked closer to limits than others, and the speaker would like to be assured that in preparing his paper the author had not used figures which some might consider out of place.

Mr. Wans had regarded depreciation from the standpoint of obsolescence only. It was very well to say that it was false economy to keep a plant in service merely because it continued to perform the duty for which it was originally installed; but the matter rested on a commercial and financial basis after all, of which the speaker's experience furnished an example. He referred to one of the earliest gas engines brought out by Crossley Brothers some thirty years ago, which was a 40-lb. compression engine, and the consumption was that to be expected in an engine of that day. The question was whether that engine was sufficiently uneconomical to warrant its replacement in view of the peculiar conditions under which it was working. It was found that, taking interest and depreciation figures similar to those put forward by Mr. Wans, a new installation would require, under the particular conditions, to use 32 cub. ft. less gas per brake horse-power for the change to be justified. That proved that the old engine, with all its defects, was commercially profitable. He did not, however, suggest that firms should keep their old engines. He merely wished that illustration to emphasise the fact that obsolescence and the period of depreciation did not rest wholly on the data given by the author, but on many others, which presented themselves to the mind when dealing with such matters. The speaker would also ask Mr. Wans why he expressed lubricating oil consumption in terms of "pint per brake horse-power." Why did he not employ the more rational basis of "per engine-hour." In conclusion Mr. Tookey thought that it would have made the paper more complete if the author had given some indication as to possible causes of waste due to mismanagement, because, in this relation, the steam engine could be made to show a much worse performance than either of the internal-combustion engines.

Mr. E. C. de Segundo also expressed a desire for further particulars on which to base a clearer understanding of the author's curves. The previous speaker had touched upon a question of considerable importance, namely, that of directive ability. It was a common experience that a plant in the hands of two different squads would often give very different results. As technical adviser he had been interested in a plant in the United States, this plant using about 400,000 h.p.-hours per month, the load being fairly constant, and running about 22 hours out of the 24 from Monday morning until Saturday night. The question arose, for the concern with which he was associated, of putting down its own plant. The price paid for power was 1.2 cent per kilowatt-hour, and in addition 200 dols. a month was paid as a flat rate; that brought out the cost at about $\frac{1}{2}d.$ per horse-power hour. Figures were gone into very carefully, estimates being furnished by the Westinghouse Company, the British Thomson-Houston Company, and others, which closely approached each other, and from the figures he had concluded that it would pay his concern to put down the necessary power plant. They had found that, taking into account 10 per cent. for depreciation and other factors, they would save 0.2 per cent. per kilowatt-hour, or 600 dols. per month (120*l.*). That seemed very desirable, but on reflection he had advised his colleagues—non-technical men—that, in his view, the factor of directive ability was of such importance in practice that it was preferable to let the supply company take the commercial risk of bad management. The breakdown and other troubles with which all who had experience of power plants were familiar were not compensated for by a saving of 0.2 cents ($\frac{1}{10}d.$) per kilowatt-hour. An inefficient superintendent could, members would agree, do a great deal of damage in a period of 20 minutes. A factor of importance was the "fool-proofness" of the power plant, and here again arose the question of the skill and ability of the staff. Indeed the great factor in the cost of production was the average skill of the workmen, mechanics, superintendents and managers engaged, a factor not always sufficiently well recognised. Youngsters and workmen were trained in theory, but not in practice; moreover, they were inadequately educated in understanding human nature. It was the complaint of many practical engineers in after-life that they would have been glad if, for half the formula, &c., they acquired in youth they could have substituted practical knowledge, particularly of human nature. That, at all events, was the speaker's experience.

Mr. Percy Griffith regarded the overload question as one of the most important points raised by Mr. Wans, who had adopted a percentage of 35 as the average in practice. The speaker's experience had been in the direction of water-works pumping and pumping engines, in relation to which, he might say, overload did not exist, the rating could be calculated in advance, the daily variations taken care of by reservoirs, and there was virtually a constant unit load throughout the life of the plant. The author's tables, therefore, would not apply to a pumping plant. On the other hand, in the case of pumping engines, when, as happened occasionally, there was a failure in the sources of supply, a condition of underload was brought about, to provide for which was more difficult than dealing with overload. In comparing the steam and internal-combustion engines he would point out that a reduced supply of water involved the necessity for running the engine at a slower speed, and therefore for a greater number of hours per day. In this respect the steam engine was much superior to the internal-combustion engine. He had come across an old steam engine, put in in 1888, which was running at about one-fourth of its speed. The speaker considered that Mr. Wans had used the term "depreciation" in a quite unusual sense, when he confined it to obsolescence. In regard to the period of 12½ years' average life, the life of a large steam pumping plant was always much longer than 12½ years. The question of obsolescence was, of course, of ever-growing importance, but he was of opinion that it should never be dissociated from repairs and renewals. He would put the case this way: that when renewing an engine something could usually be done in the way of bringing it up to date; he did not refer to wholesale changes of type and design, but to the smaller improvements made from year to year. He would ask Mr. Wans specifically whether in his capital expenditure calculations he had allowed for duplication of plant, *i.e.*, the provision of a stand-by; as unless this were adequately dealt with the effect on the client was likely to be disturbing. The author had not referred to an important distinction among the different classes of fuel, namely, that of the home-produced and the imported. Further, if the author admitted that town gas signified coal gas, might he suggest that the term "coal gas" was more convenient. He would remark here that there were few places in this country at which coal gas could be produced at 1*s.* 1*d.* per 1,000 cub. ft. Many of the author's suggestions did not apply in practice; there were a good many cases in which coal-gas engines were being used, and he must assume that such cases would have to be dealt with without the assistance of those calculations.

Mr. W. J. Marshall criticised the figures given for the economical performance of the steam engine. He thought that Mr. Wans had entirely overlooked the fact that there was in existence a thoroughly modern type of steam engine, made by the speaker's firm Messrs. Richard Garrett and Sons, Limited, and largely adopted on the Continent, known as the over-type superheated steam engine. Taking the curve for fuel consumption given in Fig. 2 of the paper, if the figures for the fuel consumption of the over-type engine were plotted, the curve would be found to be 20 per cent. lower. For instance, a 250 brake horse-power over-type steam engine would develop 1 brake horse-power per hour for 20,000 British thermal units. That was not the best figure, but was a usual working figure, which compared with that shown for suction-gas engines of equal power. Applying this correction to the tables in the paper it would be found that with free water supply the limiting price of steam coal for a jet condensing engine would be at least 25*s.* per ton, against the 16*s.* allowed by Mr. Wans, thus opening a much wider field for the application of the steam engine. The figures he had submitted were very rough, and he would like to be allowed to add a more elaborate correction by correspondence. He did not think that Mr. Wans had sufficiently considered the question of reliability. In almost every factory the actual fuel costs were somewhat small in comparison with turnover or profit. A factory requiring 250 brake horse-power running 3,000 hours a year might very well have a turnover of 300,000*l.*, and such a factory, according to the author's prices for fuel, would have a fuel bill of about 500*l.* per year. If the price of coal for the steam engine were 25 per cent. greater the extra cost would be 125*l.* a year; but if by that means 10 hours per annum for involuntary stoppages were saved, it would pay. He suggested that, in comparing the various prime movers, reliability should be given greater prominence than Mr. Wans had given it. It would then be found that the steam engine had a much greater range, especially the over-type engine, which had all the attributes of the ordinary steam plant combined with the highest economy.

Mr. Sidney Davis would like, in connection with the running costs of engines, to draw attention to the atmospheric hot-air engine. Although at present of only very small powers, these engines had proved extremely economical in running costs. Some hundreds of these engines were in use at the present time. Running costs had been carefully taken in the case of several such plants, and, in the case of water pumping, worked out at 0.75*d.* per 1,000 gallons lifted 120 ft. high. He believed that Mr. Robert Stirling was sending in a written contribution bearing on the tests of such engines (on the Stirling principle) using compressed air. This communication would doubtless be of interest.

Mr. H. S. Russell desired to defend the case of the Diesel engine, which he did not consider had been fairly dealt with in the paper. In the first place he would refer to the chairman's statement that a steam engine would last ten times as long as the Diesel engine. That was open to question; the speaker knew that Diesel engines had only been in existence some twenty-two years, and he could cite the case of a Diesel engine that had been at work for twenty years, still working as economically and well as ever. If the chairman knew of a steam engine 200 years old, and of equally sound condition, the speaker would defer to him. He thought that Mr. Wans was to be congratulated on his novel way of treating the subject of the paper; but some points were open to question and others were not quite clear. What did the author mean by a "solid-injection high-compression oil engine"? From the illustration in the paper the speaker would judge it to be a so-called semi-Diesel engine. Perhaps Mr. Wans would say if this were so, or wherein it differed. The comparisons in the paper were scarcely reliable in view of the incorrectness of the figures given for the Diesel engines. On what had the author based the figures? Cost curves were much affected by capital expenditure; some engines

would be nearly at the bottom of the curve if it were not for the capital expenditure; whereas, owing to the latter, they were nearly at the top, the Diesel engine being the highest of all. The author had left buildings and land out of capital expenditure. He would like here to point out that the Diesel engine allowed a saving in cost of land and building which quite possibly would counteract the cost of the engine itself. He had some time ago had a conversation with the managing director of a large firm doing a big business in tramways and electric power stations abroad. Inquiring why he did not seek quotations for other engines for his many schemes, his friend explained that after careful investigation the firm had found that there was no material difference in capital expenditure as between steam, gas, or Diesel engines; 5 per cent. would cover it. About 1,000 kw. was generally used at the stations. In answer to further inquiries, the speaker was told that in respect to capital expenditure the gas engine was the most costly, the steam engine came next, the Diesel engine being the lowest. Mr. Wans, however, had found the conditions entirely different. With regard to overload, it was not right to consider merely the engine-makers' rating; design of engine and other considerations entered into the question. This point had been discussed some years ago before the British Association, each speaker being asked what he considered the full load rating of an engine. The replies given were to the effect that a "full load rating" was the rating at which the engine would run continuously; not the power it would give for half an hour, often called the full load rating.

Turning to obsolescence, the speaker did not think Mr. Wans was right in applying the same figure to all types of plant. The depreciation figure, for instance, might be applicable to the steam engine, but not necessarily to the steam boiler and other plant in connection with it. He might point out that as between the suction-gas engine and the Diesel engine—he referred to municipal installations—the Local Government Board allowed ten years for the paying-off of capital in the case of suction-gas plant, but fifteen years were allowed in the case of the Diesel engine. With regard to the 3 per cent. for insurance, the speaker would say that he considered this as a method of sending up costs for engines, especially Diesel engines. He wondered where the author obtained his figure. He had taken the trouble to make a list of the insurance premiums for Diesel engines of all sizes, from 50 h.p. to 500 h.p., and had found the percentage cost for these premiums ranged from 1 per cent. to 1.19 per cent., a long way from 3 per cent., a figure which it was unfair to Diesel engine makers to put before the engineering world. The next point he would consider was that of fuel consumption. In Fig. 3 in the paper Mr. Wans had given increase of consumption with load. It was interesting to note that the curves all took the same shape, and the same shape was given for the solid-injection engine and the Diesel engine. The speaker imagined that Mr. Wans must have taken that curve from the solid-injection engine, since it was quite wrong for the Diesel engine. Mr. Russell said he had brought with him the figures, taken over many years, for the average fuel consumption of an average-sized engine, also for the fuel consumption of engines of all sizes from 100 h.p. to 500 h.p., the range dealt with in the paper. Comparing these figures with those given in the paper, it would appear that at three-quarter load Mr. Wans' figure for the increase of load was 8 per cent., whereas according to the speaker's data it was only 2.27 per cent.; the relative figures at half-load were respectively 27 per cent. as against 13.6 per cent., at quarter-load, 75 per cent. against 54.5 per cent. He would ask the use of results based upon such figures. He agreed with Mr. Tookey and Mr. Marshall in thinking that much depended upon whether figures for engine running were those obtained by the careful trial of an engine under the manufacturer's supervision or those based on deductions made by the user in actual running. Mr. Russell recalled to the minds of members the controversy in Germany, in 1909, as to the relative merits of a Diesel engine and a superheated locomobile. As a result, investigation was made throughout the country to see how far the actual running costs coincided with the figures guaranteed by the makers. It appeared that for the superheated locomobile the average consumption was 102 per cent. in excess of the rated guaranteed figures; with the Diesel engine it was 14 per cent. These figures had been actually published. The speaker could not understand the author's figures for lubricating oil. Were they for different-sized engines? The curve started lowest for the 500 brake horse-power engine, and showed a very large increase for the 100 brake horse-power engine. Were the engines of different sizes, or were the different curves for one engine at varying loads? As a result of careful tests of four different engines, taken at different times, each engine of 150 brake horse-power, he found the consumption of lubricating oil to be 0.003 pint per brake horse-power for the Diesel engine, this being lower than either the gas or steam engine figures. The author, however, placed the Diesel engine at the top of his curves and the steam engine at the bottom. In addition the speaker would say that he had had figures for lubricating oil consumption taken from some fifty or sixty different engines of all sizes over many years, and had found that the average figure was 0.004 pint of oil per brake horse-power at full working load. Of course that did not represent what the consumer had to spend, as the questions of filtering—more important in the case of internal-combustion engines than many people supposed—and settling (for re-use) had to be taken into account. But in a mining installation in England it was the practice to filter the oil several times and use it again, a practice which considerably reduced lubricating costs. Passing over certain apparent discrepancies in the author's figures for water supply to the Diesel engines, Mr. Russell went on to inquire whether any engineer with works' experience would suggest that the price for fuel oil could be lower in the case of the solid-injection engine—which he assumed to be the semi-Diesel engine—than in the Diesel engine. He would not argue upon the respective merits, but he believed that the semi-Diesel engine would not work with residual oils as Diesel engines would. In these days of expensive petroleum oils it was a great economy if an engine could be worked with, say, creosote oil. He knew of cases in which Diesel engines were working with tar oil, which cost only one-tenth of the present price of petroleum fuel oils.

Mr. Wans then replied to the chief criticisms made in the discussion. He would be pleased, he said, to do what he could in supplying the data asked for—those leading up to the curves shown in the paper. He thought the figures he had given should be regarded from the standpoint of relative value. Obviously it was impossible to give actual prices, although these had been used in arriving at results; the chief point was to work to the ratios. His endeavour had been to express the usefulness of the different engines in terms of the price of fuel, that factor regulating the scope of the engine. The several speakers on the question of depreciation had seemed to argue as though, at the end of the 12½ years, the intention was to throw the engine out; but that was not so at all. Anyone who proposed, on installing an engine, to allow 5 per cent. depreciation had not much faith in the prospect of improvements in prime movers during the next twenty years, the period required to pay off the capital expenditure. But in all cases, or at least in very many, the depreciation should be put by as a kind of sinking fund, so that when it became desirable to throw out the engine the money would be forthcoming, obviating the need for raising fresh capital, which probably was not very sound finance. The question of floor space, raised by Mr. Stromeyer, was undoubtedly important, although in many factories there was plenty of room, owing to the tendency to establish works in the country. In crowded districts, of course, the floor space was a factor which would have to be considered. Clearly, however, it was impracticable to give figures of a comparative nature; each case would have to be considered on its merits. He agreed further with Mr. Stromeyer as to the desirability of insurance and regular examination; half the trouble that arose—especially in the case of internal-combustion engines—might be avoided if owners would have their plants regularly examined. As a rule, however, slight defects were allowed to develop into grave ones, instead of being put right at once, and the repute of the engine suffered.

Mr. Tookey had asked if he (the speaker) had included everyday performances of engines; he believed he had, and, judging from the remarks of some of the speakers, particularly Mr. Marshall, he should think that he was right in that belief. The figures were not absolutely the best, but might be relied on, and were obtainable. From a severely tested engine better figures might be obtained, but were not quite suitable for the purposes of comparison. Mr. Segundo had mentioned "fool-proofness" and had dwelt on the factor of directing ability. He could only agree that if an engine were properly looked after, and the management directed their staff correctly, the insurance factor would be of smaller importance. Some while ago a man in charge of an internal-combustion engine had trouble with the big end, and believed he could improve matters by mixing a little emery powder with the oil, which, he said, would soon make a good surface. Mr. Griffith had criticised some of the speaker's figures, instancing the case of pumping engines. But he (the speaker) had stated in the paper that the figures only applied to cases in which engines were in competition, that was to say, all suitable for the particular work. He regarded the steam engine as best suited for pumping and possibly for colliery work, so that the comparison factor did not come in. Therefore the paper did not apply to pumping machinery. As to the duplication of plant, that was simply a question of doubling capital expenditure, and could accordingly be worked out. Mr. Marshall had referred to the Garrett engine, and, so far as the speaker's experience was concerned, that type of engine certainly gave the best comparison when pitted against a Diesel engine or solid-injection engine, both of which had a very high thermal efficiency. The factor of reliability emphasised by Mr. Marshall was very difficult to determine. Perhaps, however, the point was of less importance, since internal-combustion engines were reliable. There was no gainsaying that in the case of the many internal-combustion engines running week in, week out, and simply stopping for the week-end, the repair bills were small; they were every whit as reliable as the steam engine, and this applied equally also to Diesel or to solid-injection engines. Mr. Davis had submitted some interesting particulars about the hot-air engine. The speaker had not dealt with these engines in the paper, and, in point of fact, knew very little about them.

Mr. Russell, in putting a strong case for the Diesel engine, had, in the first place, inquired whether the solid-injection engine was a semi-Diesel engine; it was not. The semi-Diesel was essentially a hot-bulb engine; in the solid-injection engine the cylinder head was completely jacketed, with the result that an efficiency closely approaching that of the Diesel engine could be obtained, the only difference being that, as the name implied, with the solid-injection engine air was not used; direct injection was made by means of a pump. He was not quite clear whether in his criticism of the fuel consumption figures in the paper Mr. Russell objected to these figures being too high or too low. (Mr. Russell here remarked that he had referred to the percentage of the load.) Mr. Wans was surprised at Mr. Russell's objections, because he had actual results for the figures given, which, he believed, agreed with those of most of the authorities. He thought almost any book on the Diesel would corroborate his figures; in some cases they were even exceeded; and there was a bigger increase in fuel consumption than was shown in the curves. In reference to the suggestion that the figures were taken from the solid-injection engine, he would say that this latter engine was just as good at low loads as the Diesel engine, for which reason he had bracketed the two. If his critics disagreed with the Diesel engine figures being as high as appeared by the curves, the solid-injection engine would have to come down at the same rate; there was little to choose between these engines.

The submission of a uniform rate for depreciation

had been disapproved of, but the speaker could not see how depreciation could be otherwise dealt with. The idea of fixing a uniform rate was this, that at the end of a given number of years the engine could be thrown out should later-day practice show that the results had become uneconomical. It would be of no good to put down an engine with 5 per cent. depreciation—which commits the owner to use the engine for twenty years unless he altered the depreciation as time went on—if at the end of ten or twelve years the engine was found to be very uneconomical. In that case the loss would have to be cut and the engine thrown out; or the owner could go on running it and be out of pocket. On the question of the 3 per cent. insurance, he obtained that figure from an actual quotation. Further, he could cite a case in which the premium was quoted at 35*l.* for 500*l.* value—a higher percentage than given in his figures. With regard to residual oils, he might say that the solid-injection engine was using fuel that had given a tremendous amount of trouble in Diesel engines, simply due to choking of the fuel valves by carbon deposited in the cylinders. An engine of the solid-injection type would run for a whole week without touching the atomiser at all, the oil used having a specific gravity of 1, or a little over, and containing something like 70 per cent. of creosote; this was the average quality of the fuel now on the market. He had, in fact, not come across an oil, even tar oil, which the solid-injection engine would not use. He agreed with Mr. Russell that lower figures could be obtained for lubricating oil consumption, for the solid-injection engine as for others, but the speaker's experience of power installations showed that there was more carelessness and extravagance in relation to lubricating oil than in respect of anything else. In trying to ascertain working costs, how much each plant was going to cost, it was essential to take that factor into account. For some reason or other the ratio appeared to be constant ratio; an engine would at one moment be using 0.08 pint of oil, and a month later the results were much higher; probably the oil was to be found on the engine-house floor, not where it should be. Mr. Russell's figures did not show how many months they represented, whether they covered a period of, say, twelve months or a six-hour test; the difference would be important.

The chairman, in bringing the proceedings to a close, remarked on the valuable discussion which the paper had evoked. He was glad that Mr. Wans had agreed to provide the appendix for which he (the speaker) had asked. The paper must have taken much time to prepare, and he would terminate the proceedings by proposing the usual hearty vote of thanks to the author.

"Railway and Commercial Gazetteer."—We have received from Mr. John Gibson, 63, Coleman-street, E.C. 2, the sole agent for Messrs. McCorquodale and Co., Limited, the publishers, a copy of the seventeenth edition of "The Railway and Commercial Gazetteer of England, Scotland and Wales." The book gives the names of places arranged alphabetically, the county, population, distance from London, railway station, distance from the latter and the railways which serve such place. It measures 10 in. by 5½ in., and contains 700 pages of carefully-printed tables containing the information above referred to. Its price is 15*s.* net, and 15*s.* 7*d.* post free.

The Late Mr. Daniel Bellet.—We regret to have to announce the death, which occurred on the 11th inst., at his residence, 18, Rue des Canus, Maisons-Laffitte, near Paris, of Mr. Daniel Bellet, Knight of the Legion of Honour, Hon. Secretary of the Société d'Economie Politique, and Professor at the Ecole Libre des Sciences Politiques and at the Ecole des Hautes-Etudes Commerciales, both in Paris. Mr. Bellet was also a member of the French Institution of Civil Engineers. He frequently contributed to our columns articles dealing with French railways, canals, shipping and other industrial and commercial subjects. Mr. Bellet also contributed extensively to French, and also, before the war, to Belgian journals and magazines. He was a most prolific writer and an indefatigable worker. He has published a large number of books, including a voluminous series for the young, amongst which we may mention "La Mer et l'Homme," and "Autour de la Science." His latest publications dealt with war questions, such, for example, as "Mentalité Teutonne" and "La Commerce Allemand." Mr. Bellet was an ardent advocate of Free Trade. He was of a most kindly disposition and counted very many friends in this as well as in his native country. He was 53 years of age at the time of his death.

INDUSTRIAL NOTES.

Endeavours are at present being made to establish a national iron manufacturing concern in Holland with blast-furnaces, steel works and rolling mill. A committee has been formed for the purpose, comprising representatives of Dutch finance, commerce, industry, and shipping, and the capital required has in the meantime been fixed at the comparatively small sum of 2,500,000 gulden. It is proposed to place the works, which are intended for the production of high quality goods only, in the immediate vicinity of one of the great waterways, so that the supply of raw materials may be easy. In Holland, as in almost all neutral countries, the industry has been hampered greatly during the war from a shortage of many raw materials, and like most other countries in the same position Holland is anxious to be able to help herself, to some extent at least, for the future, although the works in question cannot be expected to come into operation before the end of the war. The annual production has been fixed at 150,000 tons to commence with, of which 100,000 tons to 120,000 tons will be shipbuilding materials and the balance more general products. Similar German establishments on the coast, which also have to import the bulk of their raw materials, have done satisfactorily, but it must be borne in mind that they have the benefit of a protective duty of some moment which the projected Dutch works can hardly count upon.

The labour conditions in Finland have apparently been entirely upset by recent happenings. Strikes appear to be the rule rather than the exception, all legal formalities of notice, &c., are a thing of the past, an increase of 100 per cent. to 150 per cent. in wages is demanded and if refused work at once stops. This was, for instance, the case on the Helsingfors-Borga railway, and the strike lasted a month. The printers acted in a similar way, an increase of 140 per cent. was asked for, and night work was to be done away with. In this case a compromise was arrived at; the men accepted a rise of 125 per cent. and agreed to resume night work. These are only a few instances, and the agricultural labourers have also caused much trouble. In Haparanda, on the Swedish side, there has also been much labour unrest. An agreement just made with the harbour hands stipulates for eight hours' work per day, at the rate of 1 krona 50 öre per hour, all overtime 100 per cent. extra; in addition, the married men obtain 12 kronor a week extra on account of the high prices prevailing, and 2 kronor per week for each child, and the single men 7 kronor per week. In cases of sickness the men have 3 kronor per day, besides free doctoring, nursing and medicine.

At the annual meeting of the Machinery Users' Association stress was laid upon the necessity of passing into law the Rating of Machinery Bill. This will abolish the present inequitable state of affairs in which whilst the stocking of a building with valuable baubles is not penalised by an additional assessment, the installation of machinery to the same value is visited by a heavy increase in the demands of the rating authority. England, it was stated, was unique in maintaining this indefensible anomaly, the necessary reform having been effected in Scotland 15 years ago, and Ireland is also free from the handicap. The reform will, of course, be fiercely fought in Parliament, and a Rating and Assessing Authorities Defence Association has been formed, mainly with this object, to the funds of which certain local authorities made illegal contributions which have had to be reimbursed.

The Sheffield Daily Telegraph reports that over 8,000 railwaymen at Derby have ceased work in consequence of a dispute between the National Union of Railwaymen and the craft union on a question of principle in connection with railway shop organisation. Two blacksmiths in the locomotive department depot who belong to the National Union of Railwaymen have, it is alleged, been persecuted by members of the Boilermakers' Union for declining to join that organisation. In consequence of this the National Union of Railwaymen at a mass meeting decided to withdraw their labour, after a deputation had interviewed the management who, not being in any way involved in the dispute, refused to intervene. The men who have already left work were engaged in the locomotive department and carriage and wagon department, and there are certain goods workers involved. At the moment the trouble is local, but as it is a question that has been at issue nationally for some time it is asserted it may become widespread. At a largely attended mass meeting on Tuesday, which was addressed by Mr. T. Lowth, assistant general secretary of the National Union of Railwaymen, a resolution was adopted agreeing, in consequence of the action of certain sectional unions, not to resume work until full satisfaction had been obtained. A further resolution resolved that, as representing between 8,000 and 10,000 railway workers at Derby, a demand should be made that the general secretary at once call the Executive Council of the National Union of Railwaymen together for the purpose of submitting the vital question of industrial organisation to the triple alliance and to solicit the whole-hearted support of the miners and transport workers.

The Right Hon. George Roberts, M.P., P.C., lit up on Saturday last, the 20th inst., the last remaining idle furnace of the Stanton Iron Works, near Ilkeston, which has been placed in commission for purposes of making basic pig-iron out of local iron ore for purposes of steel makers. The manufacture of basic pig-iron out of local ore is a new industry in the Midlands; and not until the shortage of raw materials for steel-making purposes had made itself felt were the Midlands called upon to divert their blast-furnaces to the manufacture of basic iron. It is of interest to note that under normal conditions these furnaces remain in continuous operation for some 15 years before requiring relining. The Stanton Company now have in commission nine furnaces and supply their own iron ore and coal, &c.

The Committee on Production met representatives of the engineering and shipbuilding trades on Tuesday last, to hear applications for increases under the national wage production agreement, which provides for a review of wages every quarter during the period of the war. The boilermakers and other societies asked for an advance of 100 per cent., equal to the increased cost of living, and semi-skilled trades applied for an advance of 10*s.*, with a minimum of 2*l.* 10*s.* a week. At the same time a request was put forward for a 50 per cent. curtailment of food prices generally. In all 49 trade unions, with a membership of 1,750,000, were represented. The various delegates of the trade unions expressed their serious dissatisfaction with the last award of 3*s.*, which came into operation in August, and urged that unless a more generous recognition was forthcoming on the present occasion the position would become so grave as to get beyond their control. Evidence on both sides was heard at considerable length, and at the close of the proceedings, which were private, it was announced that the decision of the committee would be communicated in a few days.

A forcible comment upon the above demand might be based on the report of a case tried during the week at Newcastle, where a plater who worked on decks and bulkheads was fined £3 for having lost time. A statement of his wages read showed that in some weeks the man had made £5 a week; another week he had made £7 odd; and another week he had made 11*l.* 5*s.* 2*d.*

Mr. Wardle, M.P., Parliamentary Secretary to the Board of Trade, received on the 19th October a small deputation introduced by Mr. Jacobsen, M.P., from the United Kingdom Commercial Travellers' Association who desired to urge on the Board of Trade that commercial travellers should be relieved of the present increases in railway fares. Mr. Wardle pointed out that the difficulties under which the British railway companies are labouring are much more severe than they were at the beginning of the year. Many more than 500 locomotives have been sent abroad for the purposes of the war, and some thousands of locomotives are awaiting repairs, which cannot be undertaken owing to shortage of materials and labour, while over 160,000 men have been released by the railway companies for military service. Although the train services have been seriously reduced a greatly increased traffic has to be dealt with by the railway companies. In these circumstances the Board of Trade desire again to urge upon the public the absolute necessity of reducing to the utmost possible extent calls upon the railway companies involved by the conveyance of passengers and goods. The Government would be most reluctant to place any further restrictions on travelling by railway, but the ever-increasing demands on the railways may make such a step necessary unless the public willingly refrain from using the railways except in cases of absolute necessity.

The Ministry of Reconstruction is taking preliminary steps towards the setting up of industrial councils of the type suggested in the Whitley Report. These councils are to be representative both of workmen and of employers. It is recognised that the rate of production after the war should be greatly in excess of peace-time precedents, and it is hoped to enlist the aid of the unions in attaining this aim, and that rules restricting output will be abandoned as neither ethically nor economically defensible. The councils will, it is hoped, also prove useful in helping towards the best allocation of the plant and materials available.

The Food Production Department, in some further

accounts of the use of tractors in agricultural work, states that the number placed at the disposal of the farmers of England and Wales now approaches 2,000, and the demand largely exceeds the supply. The latest Oxfordshire report says that 11 tractors in that county in one week each averaged 21 acres of ploughing, and two in the Chesterfield district of Derbyshire ploughed 30 acres between them. In Lincolnshire 17 tractors did 240 acres of ploughing, and the chairman of the Kesteven Committee declared that there is a growing feeling that the tractors are capable of most useful service to farmers, who can now be reckoned on to co-operate warmly with the Food Production Department in getting them well taken up. From the Holland Division of Lincolnshire, where there are 20 tractors at work, the Commissioner reports that in two or three instances over 20 acres per week have been ploughed with one tractor, and there is a great demand for the tractors.

An order has just been issued requiring, by November 1, the provision of a well-equipped first-aid cupboard in every iron, steel, and metal works for every 150 persons. Works employing 500 hands must provide an ambulance room with the usual equipment and a trained nurse in charge.

The importation of manufactured and semi-manufactured steel during last September was only about 8,000 tons, which is the smallest quantity recorded in modern times. Only 1,800 tons of billets, blooms and slabs were received from the United States. The importation of hardware was only 1,974 cwt., as against some 20,000 cwt. in the corresponding month of last year. Machinery imports, on the other hand, have risen during the year from 4,408 tons to 6,437 tons.

The Controller of the Foreign Trade Department has issued a new consolidating list containing the names of over two thousand persons and firms with whom persons in the United Kingdom are forbidden to trade under the Trading with the Enemy (Statutory List) Proclamation, 1916. Although the Statutory List has now been in existence for more than a year, cases still come to the notice of the Foreign Trade Department in which firms are corresponding with persons on the Statutory List, and they not infrequently give as an excuse that they have never heard of the list. It is important that every one engaged in foreign trade should realise that he is under an obligation to make himself familiar with the Statutory List and to observe it in his dealings. Failure in this respect renders him liable to the heavy penalties provided by the Trading with the Enemy Acts, and these apply to holding any communication whatever with anybody on the Statutory List, and not merely to entering into an agreement or continuing to carry on business with such persons. In exceptional cases where it appears to be necessary and where it is not contrary to the public interest a licence may be obtained from the Foreign Trade Department exempting from the prohibition. The Statutory List is published at intervals in a consolidated form and additions are made approximately at intervals of a fortnight. Copies of the Consolidated List and of all additional lists may be obtained at a small cost from the Superintendent of Publications, His Majesty's Stationery Office, Imperial House, Kingsway, W.C. The additional lists are also printed, as issued, in *The London Gazette* and *The Board of Trade Journal*. The lists are also circulated to a number of trade papers. Persons engaged in foreign trade should take steps to have access to one of these sources of information and should only rely on a trade journal if they have reason to know that it publishes the list in full.

Mr. John Hill, general secretary of the Boilermakers' Society, speaking at Blyth on Saturday night last, said that the boilermakers had just fixed up a very definite working agreement with the shipwrights, and in the very near future, he believed, they would succeed in forming a combination of trade unions which would dominate the shipbuilding industry in a way that had never been done in the past.

At an exhibition of women's work held during the past week at Birmingham, Mr. B. H. Morgan (Technical Adviser to the Labour Supply Department of the Ministry of Munitions) pointed to the remarkable success which had been achieved in enlarging the output of munitions and to the admirable work done by women by a division of various operations. British women were now able to do an enormous variety of machinery and fitting work, and to obtain an output which would compare favourably with any class of workers in any country. The way in which women, most of them unused to factory life, had adapted themselves to conditions and performed their work was, in his opinion, one of the outstanding features of the war. As showing what had been accomplished he mentioned that in connection with aircraft, under the direction of men, women in different shops were now making every part of an aeroplane. In this connection we may perhaps call attention to the highly improper procedure of certain firms who have sent to exhibitions of women's work parts which were actually made by men. The fraud has in certain cases been detected by the workman actually responsible for the piece. Instances of this kind naturally engender groundless suspicions as to the accuracy of the claims made for feminine efficiency. At several other works similar parts have actually been made and well made by the women.

At a meeting in Birmingham on Tuesday, organised by the Federation of British Industries and by the National Union of Manufacturers, Sir William Ashley advocated the formation of combines of manufacturers. He stated that in Germany during the war the whole of the coal industry and of the steel industry, together with all the heavy and most of the lighter metal trades, had been organised in cartels. It was not generally known, however, that during the war most of the other large industries of the country had been "compulsorily syndicated" under pressure by the German Government. If these survived Germany would come out of the war even better equipped, in the matter of organisation, for international competition than she entered it. Cheapness to-day was mainly a matter of large-scale production, and that, again, was greatly dependent on continuity of operation. And therefore the advantages of cheapness could not be secured by a combination which was satisfied to be a mere price agreement. The chief cause of the breakdown of most combinations in the past, and of the general suspicion with which they had been viewed by the public, was that they had been alliances of existing concerns to maintain prices, without any economies in the methods of production. But a combination could only commend itself to public opinion, and could only secure and extend its markets, if it could combine a reasonable profit to the manufacturers with a reasonable cheapness to the consumer. And to reach these ends under modern conditions it was becoming increasingly necessary to introduce some measure of specialisation such as might render possible the continuous employment for each process of the most suitable machinery. By economies of production "combines" could afford to pay a better remuneration to the workman. When the wage had been agreed upon by collective bargaining between bodies representing the two sides of the contract, combination could protect the standard thus reached against the short-sighted selfishness of a minority of employers.

Friction has arisen between the men employed in all grades on the Great Northern Railway, and Mr. Dent, the general manager of the company. The men contend that Mr. Dent has consistently refused to meet their deputation to discuss grievances on the ground that the deputation was a composite body, and that he would only consent to receive deputations representing the grade concerned. Arising out of this a conference was held at Grantham on Saturday of the Great Northern Railway branches of the National Union of Railwaymen, and this was largely attended by representatives of all grades throughout the system. After some discussion a deputation of nine was elected to represent the men for conference with the general manager. Another resolution was carried demanding that the company's side of the Conciliation Board should at once carry out the conciliation scheme in a broader and more generous spirit than hitherto. The resolution protested against the refusal to put items on the agenda in which the independent chairman had ruled against the company, and proposed that if the refusal is repeated the men's representatives should resign in a body. The Great Northern Railway was said to be the only company who treated their men in such a manner. On the suggestion of Mr. Thomas, however, it was decided to delay acting on that resolution until after the elected deputation had had an opportunity of meeting Mr. Dent.

Replying to a question in the House of Commons last Monday, Mr. Wardle said: "The question of distribution of trade in Durham and Northumberland among the different collieries has for some time been receiving the attention of the Controller of Coal Mines, and something has already been effected in the way of allocating trade to collieries which have been losing most time, so far as such collieries have been capable of supplying the qualities of coal required. The matter is still receiving consideration." It may be added that a Mobility Bureau is being organised with the object of finding employment for miners who have been experiencing short time in certain districts. The scheme is approved by the executive of the Miners' Federation.

Speaking at the London School of Economics last Friday, Mr. A. F. Pease, past-president of the Mining Association of Great Britain, said that the cost of coal here was now more than three times as great as in 1889. Wages were responsible for 75 per cent. of the total costs, and the Minimum Wage Act had led, he said, to a good deal of slacking. After paying all expenses, of which, as stated, wages constituted by far the largest item, the experience of Pease and Partners was that only 6 per cent. of the selling price remained for the shareholders. This would be entirely wiped out by an increase of 10 per cent. in the wages.

Sir Robert Hadfield has recently stated in *The Observer*, that before the war his firm employed 6,000 men and imported many things from Germany. They now employ 15,000 men and make everything previously imported. Working hours have been reduced, with, Sir Robert states, the most satisfactory results. The shorter hours make good men better and bring the medium workman up to something higher than the old-time average. Looking back over recent industrial history, he says that the fact becomes apparent that in the pre-war days we in England were very skilful in our efforts to impede our own progress. On one side the employers, and on the other side the men, devoted vast vital energy to the creation of great combines, each devised as if for the purpose of preventing its side from advancing. Had not Germany forced war upon us we might have had good reason to fear for the future. For years our employers had made an earnest and successful fight against the 48-hour week. Now, under war conditions, when it is necessary that we should produce at a maximum, we have turned to it as a means to just that end and find it most efficient. The hostility of the men to various progressive things was as unfailing as, for instance, their opposition to labour-saving machinery. Now they have learned that the better the tools the better the workman, and that the better the workman the better his pay. An intelligent workman should have more self-respect than is indicated by willingness to do labour which a machine could do as well. In England workers are only now beginning to realise this. The fact that workmen are not themselves machines is not yet appreciated at its full value even in America, for if workers should be too proud to rank themselves as machinery, employers should be too wise thus to rank them. All employers have been doing so.

Germany has refused to supply Dutch shipyards with steel save on conditions which will place all new construction in Dutch shipyards at the disposal of Germany and prevent any part of it from passing into the possession of the Allies. Dutch shipbuilders are required to give details not only of all ship construction and repair, but of the ultimate destination of the vessels. The shipbuilder or owner receiving German iron and steel must sign a contract, valid for five years after the war, that he will not sell any ship without giving Germany the right of refusal, and that during five years after the war he will not allow his ships to be employed, directly or indirectly, for the benefit of Germany's present enemies. The Dutch Government Iron and Steel Committee has advised builders and owners not to accept these last two conditions.

The works of the Frodingham Iron and Steel Company, in North Lincolnshire, have been purchased by Messrs. Steel, Peech and Tozer, Limited, of the Phœnix Special Steel Works, manufacturers of tyres, axles and rails, and Messrs. Samuel Fox and Co., Limited, steel manufacturers and colliery owners. All the directors, except Mr. Mannaberg, who has acted as managing director, are to retire, and their places will be taken by directors appointed by the purchasers. The works are freehold, and the iron ore is acquired from various landowners in the district. For a long time past the whole output of the concern has been for munitions and other Government requirements.

Mr. George N. Barnes has issued in amplification of a portion of his report to the Ministry of National Service the following statement of the procedure to be followed in appeals to the Enlistment Complaints Sub-Committee: A written statement setting out all the facts is signed by the claimant, and also by the officer of his trade union if the claim is to be forwarded by the union. The claim is then considered by the Munitions Area Dilution Officer, who has power to grant it, but not to refuse it. If he does not grant the claim, it is considered by the Sub-Committee. In any case of doubt, the Sub-Committee visit the place where the man is at his work, see the work in progress and interview the man. If they are still in doubt, the case may be referred to the main Committee. If the majority of the main Committee consider that further oral evidence is necessary to determine the case, such further evidence is given before the main Committee, who have the power to summon the man or his trade union secretary or any other necessary witnesses to appear before them.

THE WORKING COSTS OF PRIME MOVERS.

*A Comparison of the Working Costs of the Principal Prime Movers.**

By Oswald Wans, of Lincoln, Member.

The problem of economical power is one that must repeatedly present itself to those responsible for the welfare of industrial concerns, or indeed to any one upon whom falls the onus to provide power, for whatever purpose. Yet the available data are seldom complete, and are frequently misleading. The claims and working costs advanced in favour of the several prime movers are often conflicting and difficult to reconcile with fact. It is not suggested that a lack of good faith is responsible, as an analysis of such estimated costs generally reveals the fact that the explanation is to be sought in the too limited basis upon which the costs have been founded. The condition that a certain type of engine possesses an exceptionally high thermal efficiency does not necessarily establish its commercial superiority. On the contrary, an engine of lower thermal efficiency may, under favourable conditions, be a sounder proposition from the commercial standpoint, and this in practice is the ultimate criterion of the engine's worth.

Working costs based mainly upon the low rate of fuel consumption are practically useless, and although the statement may be termed obvious, nevertheless, not infrequently one finds that the capital charges are either inadequately covered or entirely ignored. One may allege, without feeling, that the advocates of internal-combustion engines have been the greatest offenders in these respects, but it must be acknowledged that nowadays the undertakings of manufacturers generally are based upon broader lines, due doubtless to the accumulated data consequent upon a more extended experience.

The object of this paper is to give data that will be of service in estimating capital expenditures and working costs, and in establishing the relative commercial value of the principal prime movers. For this purpose typical examples of the following prime movers will be considered :—

Suction-gas engines and plants burning anthracite, coke and wood refuse.
Gas engines using town gas.
Oil engines of the solid injection high-compression type.
Diesel engines.
Steam engines.

The scope of the paper includes units up to a working load of 500 brake horse-power, a power range embracing the engines for which there is by far the greatest demand. For higher powers two or more units can be used sometimes with advantage, for such installations possess a considerable power flexibility, in that the units may be cut out or put into service to suit the load requirements. This facility largely obviates the disadvantages of underloading, particularly valuable in the case of an internal-combustion engine, and offers a further advantage in the event of a breakdown of one unit, for a complete stoppage of work may be prevented. In a multi-unit installation the expenditure and working costs may be taken as proportional to the number of units.

It is desirable to confine the present paper to the power units indicated, as the factors governing the costs of the larger installations are distinct, for example, the possibility of using bituminous coal with a recovery plant, live and exhaust steam turbines, &c., should be considered, thus introducing another set of conditions. It is perhaps hardly necessary to state that working costs, to be of commercial value, must contain the charges due to capital expenditure, depreciation, &c., as well as those arising from the direct running expenses. Further, the latter should be founded upon "everyday" performances; the results of "kid-glove" tests should be carefully avoided.

The items constituting the total working cost are :—

Capital Charges :	Total working cost.
Depreciation.	
Insurance.	
Interest upon capital expenditure.	
Running Charges ;	
Cost of fuel.	
„ lubricating oil.	
„ water supply.	
„ sundry stores.	
„ labour.	
„ repairs.	

It is necessary to determine firstly the capital expenditure, and this factor therefore will be dealt with at once, and the remaining charges in the order tabulated. The charges arising from rent and taxes must be considered in addition, but owing to the wide variation in their amounts, it is not possible to make allowance here. They can be determined with accuracy only after a full investigation of the local conditions.

Capital Expenditure.

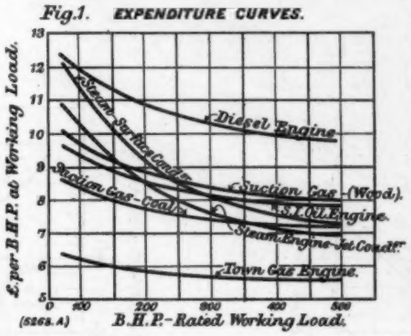
The capital expenditure should cover the total cost of the completed installation in working order. The following list gives the items included in the expenditure curves, Fig. 1.

Installation.	*Items included in Expenditure.*
Suction-gas engine. Town-gas engine. Solid injection oil engine. Diesel engine.	Industrial engine, pulley, foundation bolts, compressed-air starter with receiver and connections, exhaust pipe and silencer, barring gear, cooling tower, tanks, water circulating pipes and pump, foundations, erection.
Additional for suction-gas engine.	Producer, cleaning plant and charging platform, air and gas piping, producer foundation and bolts, erection.
Additional for town-gas engine.	Gas bag, connections and air-piping.
Additional for solid injection oil engine and Diesel engine.	Fuel tanks and piping.
Steam engine.	Industrial jet and surface condensing superheated steam engines, barring gear, foundation and bolts, steam, exhaust and feed piping, boiler, seatings and flues, superheater, feed-water heater and pump, steel chimney, economiser for 150 brake horse-power and upwards, erection.

It will be observed that buildings and flooring have not been included. These exemptions are made as their cost varies widely, being largely dependent upon the taste of the purchaser, and may therefore range from a bare galvanised structure to a substantial stone or brick building. Furthermore, existing buildings are frequently used with more or less modification.

The cost of the buildings for internal-combustion engines would be less than for a steam plant, and this applies equally to suction-gas engines, for the producer and cleaning plant do not require a covering, whereas some form of protection is necessary for a boiler. A well-equipped engine-house should possess a crane, but the cost of this item is dependent to a certain extent upon the proportions of the engine-house, and has consequently not been taken into consideration, but its cost would not be materially different for the several types of engines. Cooling towers have been included

Fig. 1. EXPENDITURE CURVES.



in all cases, with the exception of the smaller gas and oil engines of about 50 brake horse-power, as the more usual practice is to employ cooling tanks suitable for thermo-syphon circulation.

When deciding the size of the engine, it is necessary to consider its overload capacity, for this factor greatly affects the capital expenditure, the reliability, and the fuel economy. It may be remarked in passing that much of the trouble at times experienced with internal-combustion engines is solely due to excessive overloading. That gas and oil engines should have a large power margin is an essential of reliability and cannot be too strongly emphasised. The effect of the overload capacity upon the economy of an installation is dealt with later, and for the present merely its influence upon the capital expenditure will be examined. The maximum overload that may be depended upon varies considerably with the type of engine, thus :—

Steam engine	35	per cent. above rated working load.
Solid injection oil engine	15	„ „
Diesel engine	15	„ „
Gas engine	10	„ „

The larger overload carried by a steam engine is a characteristic of considerable value in the handling of fluctuating and peak loads. Moreover, this advantage is attained without impairing the fuel economy at the working load. Unfortunately this feature is not possessed by an internal-combustion engine. An overload of 35 per cent. may be carried, but only at the expense of the fuel economy at the mean working load, which in the case of a gas engine would be about 18½ per cent. below the rated working load.

The degree of importance to be attached to the overload capacity of an engine can be decided only after full consideration of the duty required, but for the purposes of comparison it is necessary that similar load conditions are considered for all installations. A common maximum load of 35 per cent. above the mean working load consequently has been assumed, and the effect upon the capital expenditure is illustrated by the table in the next column.

For a mean working load of 100 brake horse-power and 135 brake horse-power maximum load, it will be seen from the fourth column that a larger internal-combustion engine is required than is indicated by the rated working load. For example, the gas engine must have a maximum load some 23 per cent. greater than the rated maximum load usual for a 100 brake horse-power rated working load engine requiring, it follows, a larger engine and outlay than appears at first sight to be necessary.

Plant.	Rated Working Load.	Rated Maximum Load.	Necessary Increase in Rated Maximum Load to give 35 per cent. Overload.
	b.h.p.	b.h.p.	per cent.
Steam engine ..	100	135	Nil
Oil engine ..	100	115	17½
Diesel engine ..	100	115	17½
Gas engine ..	100	110	23

The expenditure curves, Fig. 1, annexed, give the total cost per brake horse-power at the rated working load, and from this it will be seen that the cost of suction-gas engine and plant of 100 brake horse-power to 110 brake horse-power is 8.3*l.* × 100 = 830*l.*, as against 8.1*l.* × 123 = 997*l.* for a 100 brake horse-power to 135 brake horse-power engine. That is to say, the cost of the gas engine is increased by approximately 20 per cent. in order that it may perform a duty equivalent to a steam engine of 100 brake horse-power rated working load. This example serves to illustrate how necessary it is when comparing capital expenditures to place the comparison on "all fours" as regards power capacity.

The expenditure curves are based upon the costs of horizontal engines, excepting Diesel engines, but would not be greatly different for the vertical type. Generally speaking, vertical engines cost more per horse-power, but a saving is effected in the cost of the foundations.

Depreciation.—A divergence of opinion appears to exist as to the annual charge that should be made to cover depreciation. The seller naturally wishes to place as favourable a complexion as possible upon the engine in which he is particularly interested, and it is to be feared that this desire tends to under, rather than over, estimation of the charges under this heading. Generally speaking, the estimated costs of steam installations show a greater uniformity and liberality in this respect than is usual with internal-combustion engines. As an example of the low rate for depreciation for the latter, the not uncommon charge of 5 per cent. may be cited. A little reflection should show how inadequate a provision this affords. It will be well to explain briefly what is here implied by the term depreciation. The depreciation charge is considered as the annual amount that should be written off the capital expenditure to cover the deteriorating value of the plant as regards obsolescence. This definition does not agree with general usage, inasmuch as wear and tear are not included.

In the author's opinion this departure is justified because :—

1. Developments are nowadays so rapid that there is an increasing tendency for a power plant to become economically obsolete before it is worn out.

2. The allowance made for repairs should be sufficient, in a modern engine, to cover wear and tear during its economical life whilst serious breakages should be covered by insurance.

Viewed from these standpoints, it follows that the depreciation charge is solely dependent upon the anticipated economical life of the installation. In other words, it is not a matter of how many years an engine may run, but for what period it can be reasonably expected to maintain its economical superiority over competing prime movers irrespective of type. Immediately this superiority is lost, the commercial value of the installation, as a source of power, falls and the advisability of replacing it by an up-to-date plant should be considered.

It is false economy to keep a plant in service merely because it continues to perform the duty for which it was originally installed. Yet it is surprising how often one finds an antiquated engine struggling along with its load, and positively eating money that could be saved by substituting a modern plant. The depreciation of 5 per cent. referred to above corresponds to a life of well over fifty years, if based upon the diminished value and allowing a high scrap value or about twenty years if taken in equal annual instalments. In either case the anticipated life is obviously excessive. The determination of this period must, in the nature of things, be somewhat prophetic, nevertheless the past, to a great extent, is an index to the future, and it may be inferred that an internal-combustion engine before the expiry of twenty years' service would be an extravagant consumer of fuel, and in a generally worn-out condition; indeed, this would be equally true of a steam installation.

The depreciation rate should spread the expenditure burden over a reasonable number of years, and permit in good time of the removal of the power plant in favour of a more modern type, should the developments in later-day practice render the running costs comparatively high. It is considered that a uniform annual rate of 8 per cent., equivalent to 12½ years' service, fulfils these conditions, and that this rate should apply to all the prime movers under consideration, seeing that the commercial life is dependent upon the best practice irrespective of the type of engine. The amount written off annually is therefore 8 per cent. of the total expenditure given by the curves Fig. 1.

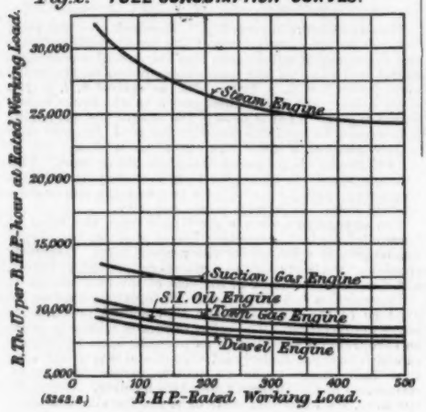
It should be noted that this uniform rate is intended to apply to cases in which the several prime movers under consideration are applicable and therefore in competition. The competitive factor applies to the large majority of installations, but there may be instances in which the working conditions render especially suitable a particular type of prime mover, thus eliminating this factor and thereby deferring the probable date at which the plant may be considered obsolescent.

Insurance and Interest.—The cost of insuring an installation is a small item and varies somewhat with

* Paper read before the Institution of Mechanical Engineers, Friday, October 19, 1917.

the power unit and the insuring company. The insurance premium for engines usually covers breakages, but not wear and tear, and this fact should not be lost sight of when fixing the annual reservation for repairs. The premiums range from about ¼ per cent. of the cost in the case of boilers to about 3 per cent. for Diesel engines. The charges under this heading are therefore comparatively small, whereas the accruing advantages are self-evident. The rate of interest upon the capital expenditure has been taken as 5 per cent. in the working-cost curves, Figs. 5 and 6.

Fig. 2. FUEL CONSUMPTION CURVES.

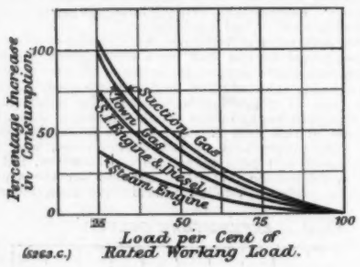


that a true comparison may be made. The following table shows the increase in fuel consumption due to the underloading necessitated by an overload of 35 per cent.

Installation.	Percentage of Mean Working Load below Rated Working Load.	Increase in Consumption due to Underloading. From Fig. 3.
Steam engine ...	Nil	Nil
Oil engine	14.5	2.5
Diesel engine ...	14.5	2.5
Suction-gas engine	18.5	12.0
Town-gas engine ...	18.5	8.0

A further allowance must be made for stand-by losses, which will depend upon the frequency and length of the stoppages. This loss of course applies only to suction-gas and steam installations, and the amount may vary considerably according to the care exercised. The following values, expressed as a percentage of the fuel consumption at the rated working load for a working

Fig. 3. CONSUMPTION & LOAD CURVES



of the wrong oil for, say, the cylinders, a mistake likely to have serious results in an oil or gas engine.

Cost of Water Supply.—In many localities a plentiful and gratuitous water service is not available, and the cost of the necessary supply becomes a matter of moment. With a free and suitable supply the water may be returned, directly after use, to the source, thus obviating the cost of a cooling plant. Frequently, however, the local charges render necessary a closed system whereby, with little loss, the water can be used repeatedly. For the smaller internal-combustion engines, up to 50 brake horse-power, cooling tanks are very general, but for larger powers a cooler of, say, the tower type, becomes necessary. The tower cooler is equally applicable for cooling condenser water and possesses the advantages of simplicity and low cost, but owing to its bulk is not always adaptable. When the requisite space is not available, a more costly form of cooler may be a necessity, but such cases are not general and must be considered individually.

In the expenditure curves, Fig. 1, page 451, the cost of a cooling tower is included for internal-combustion engines above 50 horse power and for surface, but not jet condensing steam engines. In the latter case it is

Fig. 4. LUBRICATING OIL CONSUMPTION CURVES.

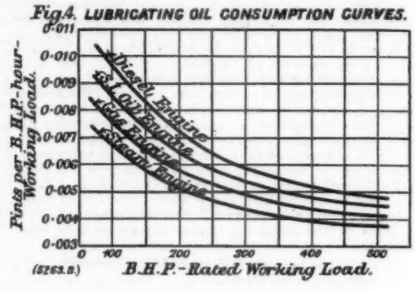


Fig. 5. WORKING COST CURVES.

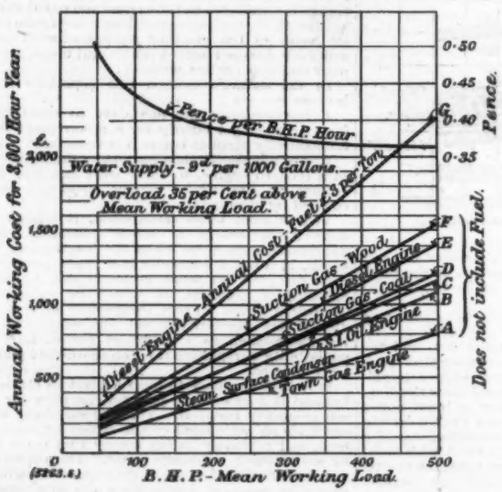
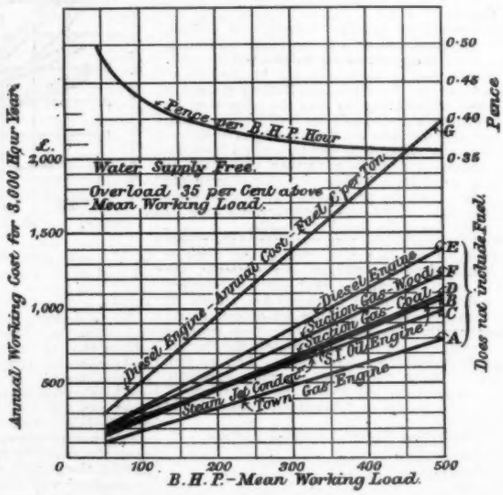


Fig. 6. WORKING COST CURVES.



Cost of Fuel.—As already stated, estimated working costs, founded upon the fuel consumption possible at the most economical load, are of little value. Everyday figures only should be considered, and failure in this respect is frequently the cause of erroneous estimates. In practice an engine seldom runs at the rated working load, having to cope alternatively with loads that may be temporarily greatly in excess and at other times considerably less. These practical conditions have a marked bearing upon the working costs, and particularly so in the case of an internal-combustion engine.

The accompanying curves, Fig. 2, above, show the average consumptions in British thermal units per brake horse-power-hour at the rated working load. These values, however, hold good only when these loads are carried continuously, and the extent to which modification is necessary to suit practical conditions is contingent upon the load factor and the peak loads to be handled. These factors may vary widely, consequently each case must be considered upon its merits, but to effect a comparison a common overload of 35 per cent. will be assumed again. This condition necessitates the underloading of all the installations with the exception of the steam plant, that is to say, the mean working load will be below the rated working load to an extent dependent upon the maximum load capacity of the unit (see tables, page 451 and next column). This underloading increases the consumption, and the curves, Fig. 3, show the average percentage increase for a given decrease in load below the rated working load.

These curves clearly indicate the importance of the correct determination of the load factor, and the absolute necessity to consider similar load conditions in order

week of 60 hours, have been included in the working costs, curves, Figs. 5 and 6.

		Per cent.
Suction-gas installations.	Anthracite ...	8
Suction-gas installations.	Wood ...	6
Steam installations ...	... ...	15

In cases where the plant runs continuously throughout the week, the losses would be considerably less and would be about one-third, assuming that the boiler or producer fires are kept alight over the week-end.

Cost of Lubricating Oil.—The quantity of lubricant necessarily varies widely in practice, even in similar engines, due partly to the differences in manufacture and to the care or negligence on the part of the attendant. To cover amply these factors, the charges should be of a liberal nature.

The accompanying curves, Fig. 4, give representative consumptions for new oil, no allowance having been made for filtering and re-using the oil. The saving effected by filtering is worthy of consideration, for it is possible by this means to reduce materially the oil bill. It should be noted, however, that filtered oil cannot be recommended for use in cylinders, unless enriched by about 30 per cent. of new oil. It will be observed that as the total quantity of oil is given, it must include both cylinder and bearing oils. For internal-combustion engines, it is customary to use one grade for both purposes, whereas two qualities are usual for steam engines in which approximately one-third of the total quantity will be required for the cylinders and the remainder for bearings, &c. The adoption of one grade of oil has a practical advantage in preventing the use

assumed that the water is run to waste. The water lost by evaporation, in passing through the cooler, may be taken as 5 per cent. of the total water in circulation.

There may be a further loss due to leakages, but in a well-kept installation the loss on this account is negligible. This cooler loss holds good for steam engines and internal-combustion engines, but there is a further loss in a suction-gas plant in the water required for supplying steam to the gas producer and in the effluent from the cleaning plant. The former water is, of course, not recoverable, and the latter can be, and is sometimes, used several times before disposal. Unless special provision is made, the water is prone to foul the circulating pump and pipe-lines, and when ultimately disposed of is apt to arouse suspicion in the municipal mind owing to its more concentrated nature, and this applies particularly to wood refuse fuel.

Often the cleaning water can be taken continuously from and returned to a neighbouring pond or river without charge. It may be remarked that the effluent, after once passing through the cleaning plant, is of a harmless nature, and if turned into a sewer or a river all traces of tar must be removed, as this appears to be the *bête noirs* of local authorities.

The table on the next page gives the total quantity of water in service and the make-up water necessary to replace the cooler and cleaning plant losses. The latter quantities only need be considered in working costs, for the cost of the initial supply of water is negligible.

Cost of Sundry Stores.—The payments arising from these items are small, and are generally covered by a charge of 0.01*d.* per rated brake horse-power-hour for any of the prime movers under consideration.

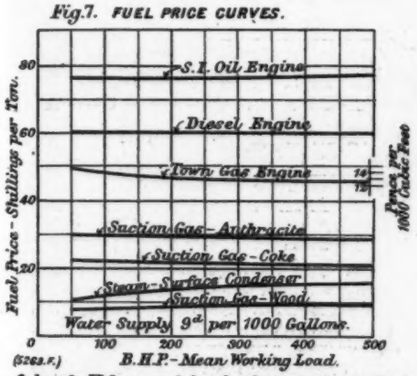
Water Consumptions.

Installation.	Surface Condenser Water. Gals. per b.h.p. hour.	Jacket Water. Gals. per b.h.p.-hour.	Piston and Exhaust Valve Gals. per b.h.p.-hour—over 100 b.h.p.	Scrubber Water. Gals. per b.h.p.-hour.	Dust Collector. Gals. per b.h.p.-hour.	Tar Extractor. Gals. per b.h.p.-hour.	Steam to Producer. Gals. per b.h.p.-hour.	Water Lost by A, B, C, D.	Water lost by Cooler Evaporation.	Total Water Lost. Gals. per Working Load. b.h.p.
				A	B	C	D			
Steam engine	45–55	—	—	—	—	—	—	—	2½–2½	2½–2½
Solid-injection oil engine	—	6	0.5	—	—	—	—	—	0.325	0.325
Diesel engine	—	5	0.5	—	—	—	—	—	0.275	0.275
Gas engine. Town gas	—	6	1.5	—	—	—	—	—	0.375	0.375
Gas engine. Anthracite and coke	—	6	1.5	1.75	—	—	0.075	1.825	0.375	2.2
Gas engine. Wood, &c.	—	6	1.5	—	4	1.5	—	5.5	0.375	5.87

Diesel and solid injection oil engines, town-gas engines ... ... 3 per cent. of engine cost.
Suction-gas installations ... 3 per cent. of engine and producer costs.
Steam installations ... 2½ per cent. of engine, boiler and auxiliary costs.

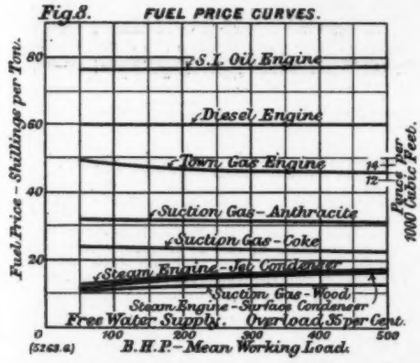
From the foregoing data it is possible to estimate with reasonable accuracy the annual working costs of the engines under consideration. These costs will be found to differ appreciably with the locality, due mainly to the fluctuations in the prices of water and fuel. The cost of lubricating oil and labour may vary, but not sufficiently to affect materially the annual charges. Further, the variation would be common to all installations, so that the relative working costs for practical purposes would be unaltered. The position with regard to the water and fuel supplies, however, is quite different. In some districts a free water supply may be available, and in others the charge may be high, whilst the price

Fig. 7. FUEL PRICE CURVES.



Calorific Values and Overloads as for Curves Fig. 8.

Fig. 8. FUEL PRICE CURVES.



Cost of Labour.—The charges under this heading should include not only the attendant's time during running hours, but also that needed to clean, grind in valves, &c., and generally to keep the installation in good condition. In the case of steam and suction-gas plants the time spent in handling the fuel and removing the ashes must be covered. The attendance time is fairly uniform for similar installations, and, generally speaking, is on a minimum basis. Usually it is not necessary to employ highly skilled labour, nevertheless sufficient should be paid to command the services of the intelligent and handy type of man. Wages at the rate of 6*d.* per hour have been allowed for in the cost curves, Figs. 5 and 6.

The following formulæ give a fair indication of the time that is spent solely upon the prime movers within the scope of this paper:—

Brake horse-power.

Suction-gas (wood fuel) and steam-engine plants	0.8+0.0047
Suction gas (coal and coke fuel)...	0.6+0.0041
Solid injection and Diesel engines	0.3+0.0036
Town-gas engines	0.2+0.0017

These expressions give the labour in hours per rated working load per hour. Thus, for a 100 brake horse-power suction-gas plant using wood fuel, and 100 brake horse-power town-gas engine, the labour would be respectively 1.27 hours and 0.37 hour per hour's run.

Cost of Repairs.—The annual charge should provide amply for wear and tear and such breakages as are not covered by insurance. The actual annual payments may form an appreciable portion of the running costs, and must in some cases exceed the estimated amount in view of the small provision made. This applies particularly to internal-combustion engines. There is little difficulty in citing instances of gas and oil engines in which the repair bill over, say, five or six years has not exceeded 2 per cent. per annum of the engine cost. Such a figure, however, should not be taken as a basis. If the cost of repairs were entirely dependent upon wear and tear, 2 per cent., there is no doubt, could be taken as a general rate. Although internal-combustion engines have proved themselves to be thoroughly reliable in service, it is nevertheless a fact that they are more prone to minor mishaps than steam engines, and due allowance must be made. For a well-designed gas or oil engine, ample margin for this contingency is given by an annual charge of 3 per cent. of the engine cost. The repair charges allowed for in the working cost curves, Figs. 5 and 6, are given in the next column.

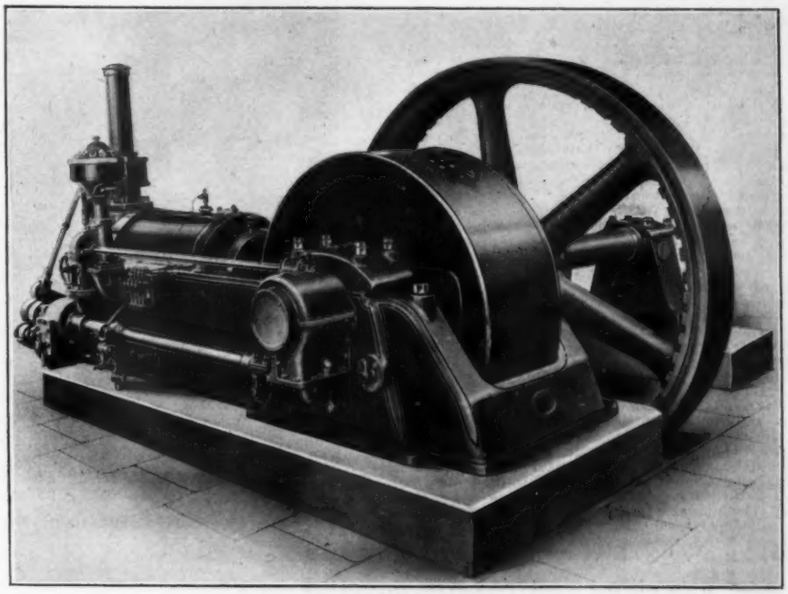


Fig 9. Solid-Injection High-Compression Oil Engine.

Fig. 10. 300-Horse-Power Suction Producer and Wood Refuse used therein.

of fuel, particularly oil, varies considerably from time to time and with the locality, thus rendering these two items almost the ruling factors of economical working.

In order to establish a relationship between the fuel prices that may be paid, and to show the influence of the water charges upon these prices, the curves, Figs. 5 and 6, have been plotted. The curves A to F, Fig. 5, give the annual charges with water at 9*d.* per 1,000 gallons, and in Fig. 6 it is assumed that the water supply is free, but none of these curves includes the cost of fuel. The curves G represent the total annual working cost of a Diesel engine using fuel oil at 3*l.* per ton. It follows,

therefore, the total amount that may be spent annually upon fuel to give even running charges for any one of the remaining installations is represented by the length of the ordinate between the curve G and the cost curve of the particular engine considered. From the total fuel cost thus obtained the maximum prices that may be paid can be easily computed, and have been plotted in curves Figs. 7 and 8, whilst the fuel prices given by those curves for plants of 250 brake horse power mean working load are given below :—

—	Price of Fuel. Curve Fig. 7	Price Ratio.	Price of Fuel. Curve Fig. 8.	Price Ratio.
	per ton.		per ton.	
Diesel engine	60 0	0.79	60 0	0.785
Solid-injection oil engine	76 0	1.0	76 6	1.0
Suction gas. Anthracite	29 0	0.38	31 6	0.41
Suction gas. Coke ..	21 0	0.27	23 0	0.3
Suction gas. Wood ..	8 6	0.113	12 0	0.157
Steam engine. Jet condenser	—	—	16 0	0.21
Steam engine. Surface condenser	14 0	0.184	15 0	0.195
	per 1,000 cub. ft.		per 1,000 cub. ft.	
Town-gas engine ..	1 0	0.014	1 1	0.014

In the curves, Figs. 5 to 8, the engine possessing the highest thermal efficiency, namely, the Diesel engine, has been taken as a convenient basis using fuel oil at 3*l.* per ton. Reference to these curves shows that the relative fuel prices for the several installations are fairly uniform for the range of powers under consideration. The widest variation is that shown for the steam plants, due to the comparatively higher initial cost and lower thermal efficiency of the smaller-powered engines. It should be noted that the fuel consumptions represented by the curves, Fig. 2, are favourable to the steam engine, and apply to compound condensing installations using superheated steam, that is to say, they are best practice figures. It may be said with certainty, therefore, that in general practice consumptions as much as twice those represented are not unusual, thus nearly halving the fuel prices shown by the fuel price curves, Figs. 7 and 8, and further limiting the districts in which the use of the steam engine can be defended on the score of minimum working costs.

As the power increases a higher price may be paid for coal, and the steam engine becomes a more serious rival of the suction-gas plant; nevertheless, for installations up to 500 brake horse-power working load the latter well holds its own, for it is possible to obtain even-running costs with fuel ranging in price, according to the power, from two to three times that permissible for a steam plant. The price allowable for town gas is practically constant at 1*s.* 1*d.* per 1,000 cub. ft., and consequently confines the use of the town-gas engine to cities in which gas is procurable at this low rate.

Turning now to the high-compression solid injection-oil engine. A high price may be paid for fuel oil, namely, 3*l.* 16*s.* per ton as compared with 3*l.* for the Diesel engine, or a price some 26 per cent. higher, notwithstanding the higher thermal efficiency of the latter engine. The lower capital expenditure and other running charges of the solid-injection engine are responsible for this result. The future of the oil engine must be obviously dependent upon a regular supply of uniformly low-priced fuel oil, and it is to be feared that past irregularities in these respects have to a certain extent militated against their more extended application.

The problem of the supply of a uniformly low-priced fuel-oil is one that is well worth the serious consideration of the large oil companies, and it is satisfactory to note that during the twelve months prior to August, 1914, one company had gone a long way to establish a feeling of security amongst users of oil engines by offering fuel at an average price of 3*l.* a ton, and were prepared contract for a regular supply over several years. There seems to be every probability of these conditions again becoming general after the war. An adequate supply of fuel oil, in view of the high thermal efficiency of the oil engine, is of the utmost importance to manufacturers, for it offers a means by which minimum working costs may be obtained. It is usual, in the supply of electrical and hydraulic energy for power purposes, for the suppliers to charge specially reduced rates, and it is suggested that a similar procedure might be followed with advantage in the case of fuel oil.

With fuel oil at 3*l.* per ton the price of coal must not exceed on the average 1*l.* 5*s.* and 12*s.* per ton respectively for suction gas and the larger steam plants over 250 brake horse-power in order that the total annual running charges do not exceed an oil engine of the solid-injection type, clearly indicating the wide field of action of this type of engine. The cheaper grades of fuel oil of not less than 0.95 specific gravity alone are considered, as the charges of engines using the more costly and refined oils are appreciably higher and therefore commercially inferior. In Fig. 9, page 453, is shown a high-compression oil engine of the solid-injection type, capable of handling the cheapest fuel oils with an economy in conformity with the curves, Fig. 2, page 452.

Considering lastly the refuse suction-gas plant, the price of the fuel, ranging as it does from 11*s.* to 13*s.* per ton, even with a free water supply, limits its use to industries in which the wood or other combustible refuse is a waste product of the industry, for it is seldom possible to obtain a constant supply at these rates. Under this condition refuse installations are unquestionably the cheapest form of power. The illustration, Fig. 10, page 453, shows the producer of a 300 brake horse-power suction-gas installation working entirely upon sawdust, shavings, wood blocks, &c. A producer of this type will also handle such refuse fuels as various kinds of husks and nut shells, bark, spent tan, plum stones, &c. The kind of refuse used in the producer is illustrated in Fig. 10.

The use of suction gas as a heating agent is yet in its infancy, but very satisfactory results have already been obtained in laundries, woodworking factories, tinsmiths' shops, &c. The gas is drawn from the producer through a purifier and pumped to a gasholder, from which it is piped under slight pressure to any part of the factory, and by the aid of an air-mixer and burner used in a similar manner to town gas. This feature is worthy of consideration, for it adds to the general utility of the suction-gas installation, and may in some cases effect an appreciable economy in the working costs. The plant, Fig. 10, supplies gas for heating purposes in addition to that required for power. The possibilities and the refuse suction-gas installations to industries in which there is an ample supply of suitable waste material.

It is obvious, therefore, that the commercial superiority of a prime mover is not established by reference to its thermal efficiency, but by the local conditions regulating the price of fuel. From the purely engineering point of view this is not entirely satisfactory in that, however thermally efficient an engine may be, the ultimate test is a commercial one involving the market price of fuel, which must always depend upon the facilities for distribution from the source of supply. In practice, therefore, railway and shipping freights have a marked and direct influence upon the type of engine giving the most favourable performance from the commercial standpoint.

The whole problem is one that cannot but force itself more and more upon manufacturers with the keener competition that may be expected in the near future, and unless correctly solved must tend to handicap any industrial concern as the result of the higher establishment charges that must necessarily follow. The right solution not only benefits the manufacturer, but also effects an economy in the national resources by preventing the waste of fuel so frequently met with in practice, suggesting that minimum costs are either not sought or that the regulating conditions are not fully appreciated by those responsible.

Fig. 11. Boiler Heated by Exhaust from 250 B.H.P. Suction-Gas Engine.

of the system suggest many applications in which economies could be effected.

An objection sometimes advanced against the adoption of the internal-combustion engine for certain classes of works as, for example, tanneries, laundries, cotton mills, factory heating, &c., is its inability to provide a steam supply. This difficulty has, however, been met to a large extent by the exhaust-heated boiler, which is capable of supplying about 2 lb. of steam from and at 212 deg. F. per brake horse-power-hour of the engine. The steam being generated from the exhaust heat that would otherwise be wasted may be truly stated as costing nothing beyond the small additional charges due to depreciation and interest upon capital. The illustration, Fig. 11, above, shows a boiler working in conjunction with a 250 brake horse-power suction-gas engine, and is capable of supplying about 500 lb. of steam per hour, which is equivalent to the saving of 65 lb. of coal per hour.

Conclusion.—It is evident from the foregoing that statements to the effect that a certain class of engine is the most economical requires qualification. It has been shown that the cost of fuel has a deciding influence upon the working cost, although that due to the necessary water supply may be serious in some districts. Now, as the cost of fuel is regulated largely by railway and shipping freights, it is clear that the distance from the source of supply has an important bearing upon the kind of fuel, and, it follows, the type of engine that should be installed.

The maximum permissible prices that may be paid in any locality are indicated generally by the ratios, in the table, and more particularly by the curves, Figs. 7 and 8, page 453. The practical application of these price ratios shows that each type of engine has its particular field of action in which it can be used with commercial advantage, provided due regard is paid to the local conditions, or in other words, an exclusive claim to minimum working costs cannot be rightly made on behalf of any one of the prime movers under consideration.

The relative fuel prices do, however, indicate that the scope of the steam engine is less than the oil engine, for in the best practice of the former the price of coal for the larger installations of 250 h.p. and upwards may not exceed on the average one-fifth of the price of fuel oil for an engine of the solid-injection type and one-fourth for Diesel engines, and appreciably less for smaller powers. Between these extremes stands the suction-gas plant, for which the prices of coal and coke may be respectively twice and 1½ times the price of coal for steam engines of the larger powers. The use of town-gas engines is clearly confined to the few cities in which gas can be obtained at about 1*s.* 1*d.* per 1,000 cub. ft.,

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Lloyd's Diagram for Calculations.—At the present time, when the cost of slide rules has increased so rapidly, the appearance on the market of an ingenious diagram, with which all slide-rule calculations can be done, is of interest. The diagram, which has been devised by Mr. H. G. Lloyd, A.C.G.I., M.Inst.C.E., consists of a number of straight lines so arranged that the results of calculations may be rapidly obtained without the use of a straight edge or other accessory. A somewhat unique method of edging the lines with colour enables the eye to read the scale without having to follow each line. The diagram is published by Messrs. E. and F. N. Spon, Limited, and is obtainable through a bookseller for 2*s.* 6*d.* mounted on cardboard for office use (13 in. by 8¾ in.). It is also being issued in a handy pocket form, rolled up in a metal case 8 in. by ½ in. diameter, at 5*s.*

Diesel Engine Users' Association.—The meetings of the Diesel Engine Users' Association have been resumed after the summer recess. The president, Mr. Geoffrey Porter, reported on the position in regard to the supply of tar oils as Diesel engine fuel, as discussed with the Director of Munitions Petroleum Supplies. In the discussion which followed the difficulty of making satisfactory arrangements for continuous supplies of fuel for the short periods allowed by the licences issued by the Director of Munitions Petroleum Supplies was referred to. The hon. secretary produced the figures of the Diesel engine plant at Chelsea, in which case the consumption of 700 tons of fuel oil per annum resulted in the replacement of a total weight of 6,000 tons of coal per annum, which would otherwise have had to be transported by the railways, and which would have produced about 500 tons of clinker and ashes, for which cartage facilities would have had to be provided. Mr. H. S. Russell read a very interesting paper on "Automatic Control of Blast Pressure for Diesel Engines," in which he described the construction and working of Messrs. Mirrlees, Bickerton and Day's apparatus for regulating the blast.